SEP 3 1924
PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CXVIII.—No. 3060.] *LONDON: FRIDAY, AUGUST 22, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

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Bills of Quantities, etc., and Forms for Tender may be obtained from the Contracts Branch, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to THE SECRETARY, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. F 639

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TO STEEL STRUCTURAL ENGINEERS.

The Water Committee invite

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Form of Tender, Specification and conditions may be obtained on application to the Water Engineer, Plymouth, accompanied by a deposit of two guineas which will be refunded on receipt of a *bona fide* Tender.

Sealed Tenders, endorsed "Tender for Bridge" must be delivered to the undersigned not later than Monday, September 22nd, 1924.

The Committee do not bind themselves to accept the lowest or any Tender.

FRANK HOWARTH, M.Inst.C.E., Water Engineer.

Stonehouse Town Hall, Plymouth.
August, 1924. F 575

CITY OF LIVERPOOL.

WATER ENGINEER'S DEPARTMENT.

CONTRACTS FOR THE SUPPLY OF MATERIALS.

The Corporation are prepared to receive

Tenders, Covering the Period

of Six months ending 31st March, 1925, for the SUPPLY of the undermentioned MATERIALS, viz.:—

1. BRASS CASTINGS AND FITTINGS.
2. MISCELLANEOUS IRON PIPES AND CASTINGS.
3. SLUICE VALVES.

Separate Tender Forms, including Specification and Schedule, for any of the above items will be forwarded upon receipt of application in writing to the Water Engineer, Alexandra Buildings, 55, Dale Street, Liverpool.

Duplicate Forms of Tender for record purposes will not be supplied.

Tenders must be sealed and enclosed in the official envelopes provided, endorsed in accordance with the instructions in the Form of Tender, and FORWARDED THROUGH THE POST, addressed to "The Town Clerk, Municipal Buildings, Liverpool," so as to be delivered not later than Ten o'clock a.m., on Tuesday, the 2nd September, 1924.

WALTER MOON, Town Clerk.

19th August, 1924. F 629

COUNTY OF LONDON.

DISPOSAL OF TRAMCAR CONTROLLERS, MOTORS, ETC.

The London County Council will have

For Disposal, at the Tramways

Car Shed, New Cross, or the Central Car Repair Depot, Charlton, approximately every four weeks during the next twelve months, certain EQUIPMENT, comprising Electric Car Controllers, Motors, Circuit Breakers and Canopy Switches of the undermentioned types:—

CONTROLLERS.
Westinghouse, 90M.
Dick, Kerr, D.R.I., Forms D. and G.

MOTORS.
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Dick, Kerr, 3a and 25a.

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CANOPY SWITCHES.
Westinghouse, Style No. 5409.
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Persons, firms, tramways undertakings, etc., desirous of tendering for the purchase and removal of such equipment should apply to the Chief Officer of Stores, L.C.C. Stores Department, The County Hall, Westminster Bridge, S.E.1.

Forms of Tender, containing full particulars will be sent to applicants as the equipment becomes available.

JAMES BIRD, Clerk of the London County Council. F 618

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The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

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(C) LAVATORY FITTINGS.
(D) 800 YDS. MOSQUETTE CLOTH.
(E) 562 TYRES FOR ENGINES AND TENDERS.
(F) 3450 GALVANISED ROOF SHEETS.

For each copy of the Specifications (A), (B), (C) and (D), a fee of 10s. will be charged, and for each copy of the Specifications (E) and (F), a fee of 20s. will be charged, which fees are not returnable.

Tenders, enclosed in sealed envelopes, addressed to "The Chairman and Directors," and endorsed "Tender for Girder Bridges," or as the case may be, must be delivered at the Company's Offices not later than Noon on the following dates:—

Tenders for (D) and (F), on MONDAY, 1st SEPTEMBER, 1924.
Tenders for (B), on FRIDAY, 5th SEPTEMBER, 1924.
Tenders for (A), (C) and (E), on MONDAY, 8th SEPTEMBER, 1924.

The Directors do not bind themselves to accept any or the lowest Tenders, and reserve the right to divide the orders.

By Order of the Board.
F. C. FRANKS, Secretary.

199, Gresham House, Old Broad Street, London, E.C.2.
21st August, 1924. F 638

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DIRECTORATE OF RADIOLOGICAL RESEARCH.

ASSISTANT II.

Required, One Physicist.

Candidates must possess an Honours Degree in Physics and at least three years' experience in research.

Initial salary £260 and bonus (total emoluments at present approximately £377). The post carries superannuation under a scheme similar to that of the Federated Universities. Annual leave, six weeks. The first year will be regarded as probationary.

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from duly Qualified Candidates for APPOINTMENT to the above POST in INDIA.

Qualifications:—Candidates must have had a good general and technical education, and obtained a degree at a recognized Engineering College or passed the Associate Membership Examination of the Institution of Civil Engineers. In addition they must possess at least one year's practical experience with a Railway Company or on public works.

Salary:—Up to Rs. 500 per calendar month to commence, according to age and experience.

Terms:—A three years' agreement in the first instance, first-class free passage to India, and home again on satisfactory termination of service. Privilege leave and furlough in accordance with the Rules in force.

Applicants must send in to the undersigned a record of their career in chronological order (with dates) and COPIES ONLY of testimonials, Service Certificates, etc., giving name of firm where pupilage was served and of subsequent employers, with short details of work in each case, and with particulars of general and technical education, honours, etc., gained, not later than the 30th August, 1924.

F. ADAMS, Secretary.

Offices of the Company:—
50, Old Broad Street, London, E.C.2.
14th August, 1924. F 606

THE MUNCIPALITY OF SINGAPORE.

STRAITS SETTLEMENTS.

SUPERINTENDENT OF FITTINGS—GAS DEPARTMENT.

The Municipal Commissioners of Singapore require a

Superintendent of Fittings for

the Gas Department, age about 25, well educated, of sound constitution, and unmarried. Candidates must have a good practical knowledge of gas fittings, main and service laying, and general district maintenance work. The selected candidate must be of good education and address, as the Municipality lay on all services, together with internal fittings to private buildings, and the person appointed will come into contact daily with consumers, in case of complaints or new fittings, etc., whose requirements he will be expected to satisfy. Preference will be given to an experienced candidate who has been employed as a District Inspector, and the duties are those usually carried out by a Superintendent of Fittings. The selected candidate would work directly under the instructions of an Assistant Gas Engineer in charge of District work. The appointment will be on agreement for three years with possible extension. The selected candidate must pass a medical examination as to his fitness for service in Singapore. A passage will be provided with half-salary during the voyage out. The salary will be 4560 dollars for the first, 5040 dollars for the second, and 5520 dollars for the third year, paid monthly, the value of the dollar being two shillings and four pence sterling. For the first year the salary would be equal to £570 as above, with an allowance for such transport as may be required on duty.—Applications, stating age, place of birth, and giving details of education, training, and experience generally, stating when free, accompanied by copies (only) of testimonials, and also personal references, to be lodged with Messrs. C. O. LINDSAY & PEIRCE, M.M.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Municipal Commissioners (from whom further information may be obtained), not later than Tuesday, 2nd September, 1924. F 619

The Royal Air Force

REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, ENGINE DRIVER FITTERS, POWER STATION ENGINEERS and WIRELESS OPERATORS. Age limits 18 to 30. Pay from 24/8d. to 38/6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. F 616

Competent Electrical Engineer

REQUIRED for modern factory development work. Experienced in A.C. and D.C. generation and distribution, electric welding, power and lighting installations. Progressive appointment for right type of man.—Address, stating age, experience, qualifications, when disengaged, and salary required, F 635, Offices of Engineering.

THE FREE DISCHARGE OF LARGE VOLUMES OF WATER.

WHEN releasing deep impounded waters, or discharging high-pressure water freely into the air, two important considerations arise. On account of the large amount of energy released under such circumstances, which has in some way or other to be absorbed, there is great danger of causing destruction to banks, channel beds, or dam foundations in the neighbourhood of such outlets. In cases where the outlet is controlled by some form of sluice valve, operation at partial opening is often necessary, resulting almost invariably in serious erosion of the metal parts of the sluice. It may be recalled that attention was drawn to these points in a paper entitled "Improvements in Mechanical Contrivances in Connection with the Storage and Distribution of Water," read by Mr. E. Bruce Ball, of Messrs. Glenfield and Kennedy, Limited, before the Institution of Mechanical Engineers, at its summer meeting held in Glasgow in 1923.* In this paper Mr. Bruce Ball referred to an appliance designed to effect the delivery of high-pressure water, under the conditions mentioned above, and gave an hydraulic diagram explanatory of the purpose in view, as well as an example of sluice-valve erosion. The apparatus described by Mr. Bruce Ball involves the creation, at the outlet of the jet, of a free vortex, the effect of which upon release at the mouth of the valve, is to cause the jet to break up into an immense number of small drops, which are cushioned against the air, and fall on to the surface of the stilling basin, the destructive energy of the jet being entirely dissipated.

The outlet to the Cray Reservoir of the Swansea Corporation Waterworks presented a discharge problem of the character under consideration, and the possibility of improving the conditions resulted some time ago in Mr. G. R. Collinson, B.Sc., M.Inst.C.E., then water engineer and manager at Swansea, conducting some experiments, the results of which Mr. Collinson has lately placed in our hands. The outlet to the Cray Reservoir is controlled by two 36-in. sluice valves in series, which had never been fully opened since their installation. On the single occasion when the valves were opened as much as 14 in. a hole was washed in the opposite bank 80 ft. away over the top of a retaining wall 8 ft. high. Subsequently the valves were not opened more than 6 or 7 in. Jet-dispersers of the free-vortex type above referred to, supplied by Messrs. Glenfield and Kennedy, were fitted in turn to the outlet, and their behaviour under test is illustrated in the accompanying figures. Of these, Figs. 1 and 2 show the hydraulic conditions, Fig. 3 shows one of the jets delivering into the outlet pool, while Fig. 4 is a near view of the jet showing the spiral form acquired by the stream of water.

It was found possible with this apparatus to open the sluice valves to their full extent. One disperser passed about 335 tons of water per minute under a head of nearly 85 ft. This amount of water was dropped over an area of 835 sq. ft. on to the surface of the shallow outlet pool barely 2 ft. deep, with hardly any disturbance in the pool and without the slightest risk of damage to the surroundings. The water is emitted under these conditions as a solid jet with a velocity of nearly 64 ft. per second. Before escaping it has imparted to it a free-vortex motion, the centre of which rotates more quickly than the periphery. After release the centre water takes a more divergent course than the outer water, so that the whole body is a mass of interlacing filaments and is shattered into millions of tiny globules or rain-drops. These drops at their high initial velocity are subject to very great air resistance, and they eventually fall harmlessly over an area many times greater than that of a solid jet delivering the same volume.

Taking the average size of the drops as $\frac{1}{8}$ in. in diameter, something like 345,000,000 drops would be formed per second. The dispersion area is an approximate ellipse 56 ft. by 19 ft., with a surface of 835 sq. ft. This is 216 times the area of the solid escaping jet, the disperser being 24 in. in diameter. Allowing equal spacing and air gaps the average number of drops per square foot would be 413,000 per second, and their average vertical velocity at the water surface rather less than 1 ft. per second. The apex angle at the disperser is 32 deg. There was no contraction of the escaping jet at the outlet. The diagram shows that 1,750 shock horse-power at the outlet were completely dissipated at the water surface.

In Figs. 1 and 2 the hydraulic gradient is shown to a scale corresponding to that of the dam. The virtual gradient is to a similar scale but is measured from the down-stream water level. The energy present is 22·68 times the ordinate of the virtual head graph.

In the Cray reservoir experiments the disperser proved successful in overcoming the difficult problem of safely releasing large volumes of high-pressure water freely to the atmosphere. Incidentally the very thorough aeration of the previously stagnant impounded water is a valuable feature of the disperser action so far as waterworks practice is concerned.

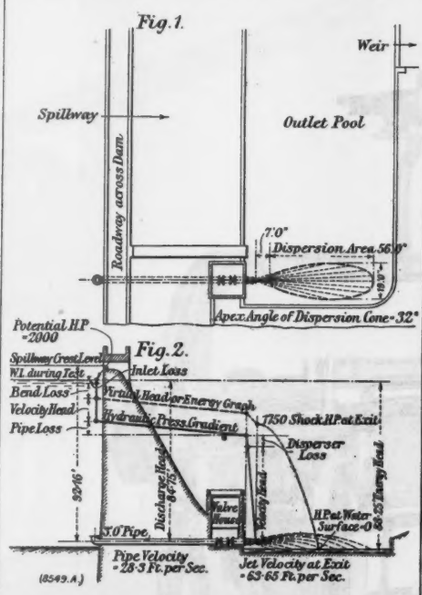


FIG. 3. VIEW SHOWING JET DISPERSER DISCHARGING INTO OUTLET POOL.

FIG. 4. NEAR VIEW SHOWING SPIRAL FORM OF DISCHARGE FROM JET DISPERSER.

* See ENGINEERING, vol. cxvi, page 31.

THE MACHINERY OF THE COTTON MILL AT THE BRITISH EMPIRE EXHIBITION.

(*Concluded from page* 91.)

AFTER doubling, the corded and combed spun cotton yarns still show projecting ends of fibres when viewed in a good light, and these increase the diameter of the yarn and make it coarse without giving strength to it. Singeing or gassing is used for the removal of these loose projections, and adds greatly to the delicacy and fineness of the appearance of the yarn and of the material produced from it. The process consists in passing the yarns very rapidly through a hot gas flame. A speed is used which is just sufficient for the removal of the projecting ends, but is too great to permit the burning of the body of the yarn. Another process that is used to obtain suitable yarns for lace making and other special purposes is known as preparing. It is a calendering process performed on the yarn in hank form with very heavily weighted calender bowls. By it the roundness of the yarn is diminished and a lustrous or polished appearance is obtained. Before being passed on to the looms for weaving the yarn intended for the warp threads, that is to say, those that run the length of the cloth are sized to give them additional strength to meet the conditions found in weaving as well as to give them a certain polish. The percentage of the added weight of size to that of the original yarn varies most extensively, but in some classes of goods, for example, those which will be subjected to the processes of bleaching, dyeing or mercerising, only the amount necessary to ensure successful weaving is required, which for other classes much excess of this are used. The materials employed are flour, farina, China clay, paraffin wax, tallow, magnesium sulphate and chloride sodium sulphate and zinc chloride.

Weaving is the process by which the threads made up of cotton fibres are so interlaced with one another as to form cloth. Two sets of threads are requisite, the warp ones, already referred to as those which run the length of the fabric, and the weft ones which run across the cloth or at right angles to the warp. For the purposes of weaving, whatever machinery is used must be capable of repeating successively the shed or separation, by lifting or lowering, of some of the threads from the total quantity, the carrying of the weft thread through between them and finally bearing-up this thread to join the body of the fabric. The loom must perform these three actions as well as take up the cloth produced and wind it on a roll. The customary provision in textile machines of mechanism to stop the operations on the breakage of a thread is also essential for the avoidance of waste of time and material.

In the old hand loom for weaving plain cloth the shed was made by the weaver operating treadles,

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

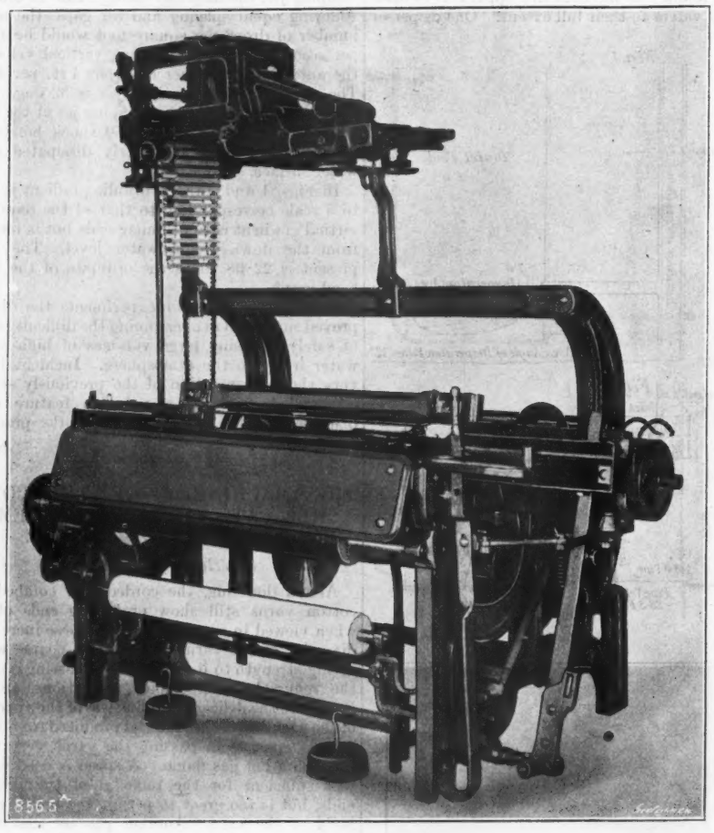


Fig. 26. Underpick Loom with Dobby; Messrs. Richardson, Tuer and Co., Limited, Farnworth.

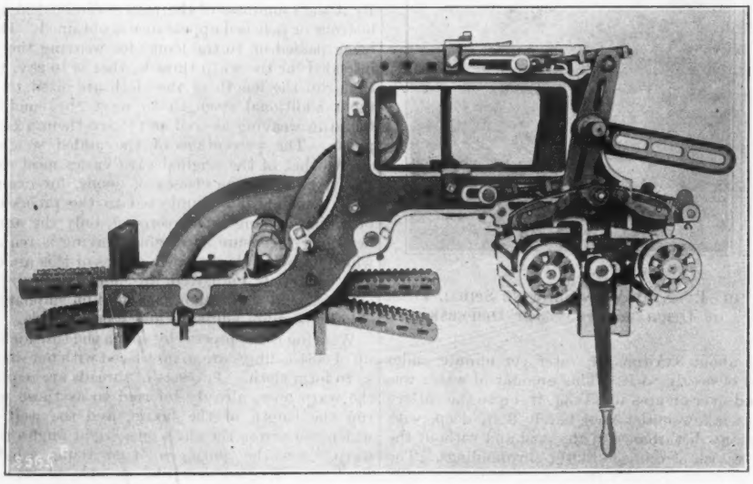
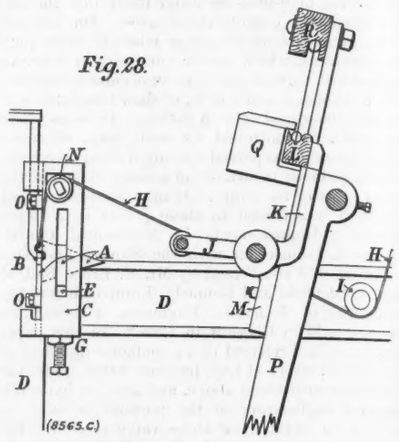


Fig. 27. Climax Dobby; Messrs. Lupton and Place, Limited, Burnley.

the levers from which were so connected that when one was lifted the other was depressed. By the alternate movements of the treadles the separation of the threads in the process of shedding was carried on continuously. The weft thread was then passed between them as the shuttle from which it was obtained was thrown across the loom from one side to the other. Hand looms are now entirely out of use in the cotton trade, and the old processes performed by them are now done much more quickly in power-driven machines. In addition to the advantage of speed modern looms are capable of performing much more complicated work. Many different types of device are in use for the performance of the shedding process, which either raise one set of threads and leave the others in their old position, or give a rise to the one set and a fall to the others. The actual movement is effected by the use of healds which are loops of twine with or without eyes through which the warp threads pass. These healds are raised or lowered by many different types of mechanism, some of which will

Fig. 28.



be described later. The threads after passing through the healds go through the teeth of wires within a closed frame known as the reed. This is carried by what is termed the slay which has a way provided in it for the passage of the shuttle. The arms of the slay are carried down to the base of the loom frame, where they are centred. By means of crank arms this system is given a reciprocating motion, when the shed is made in the warp threads, a sharp blow is given to the shuttle, and sufficient velocity is imparted to it to carry it quickly to the other side of the machine. This action is effected by motion obtained from a cam through a picking stick. It should be noted that such propulsion of the shuttle through the shed is known as a pick. After the weft thread is in place it is beaten up against the fabric by the forward movement of the slay.

The healds are raised and lowered by the use of tappets, barrel motions or dobbies. The name tappet is given to the mechanism by which a rotary motion is converted into a reciprocating one for a series of levers. Should the motion be such that after a series of lifts there is a period of rest the mechanism is called a tappet, but other terms such as cam and wiper are used when the motion is continuous. Such arrangements are limited in their application, because they cannot be used if a large number of shafts must be manipulated, or a large number of picks are necessary for the making of a single repeat on the pattern. For the mechanism known as the dobby, motion is taken from the bottom shaft of the loom to work a rocking lever on a horizontal axis which has what are termed knives at its two ends. These are constrained to move horizontally, one moving in as the other moves out. Projections on the ends of these knives impart motion to arms pinned to a frame from which motion is obtained for the jack lever which causes the shed. All this mechanism is duplicated for each shaft. The momentary location of the horizontal levers of the frame, which get their motion from the knives, determines whether a rise or fall is given to the warp, and this is controlled by raising and lowering the frame arms by pegs on a series of boards or lags which work round a cylinder or barrel. An example of a dobby of the Ward type is shown in Fig. 26 on this page, fitted to a standard underpick type of loom with a reedspace of 38 in., made by Messrs Richardson, Tuer and Co., Limited, of Hope Foundry, Farnworth. This dobby has 16 shafts, and its use makes possible the production of a great variety of work. The underpick type of loom is not used to anything like the extent of the overpick type, but the speed of its operations is not much less than that of the more common machine. It is very easy of adjustment and is capable of adaptation to a very wide assortment of work, especially when a shuttle-changing mechanism is included in its equipment.

The Climax dobby (Fig. 27), made by Messrs. Lupton and Place, Limited, of Queen-street Iron-

TEXTILE MACHINERY; BRITISH EMPIRE EXHIBITION.

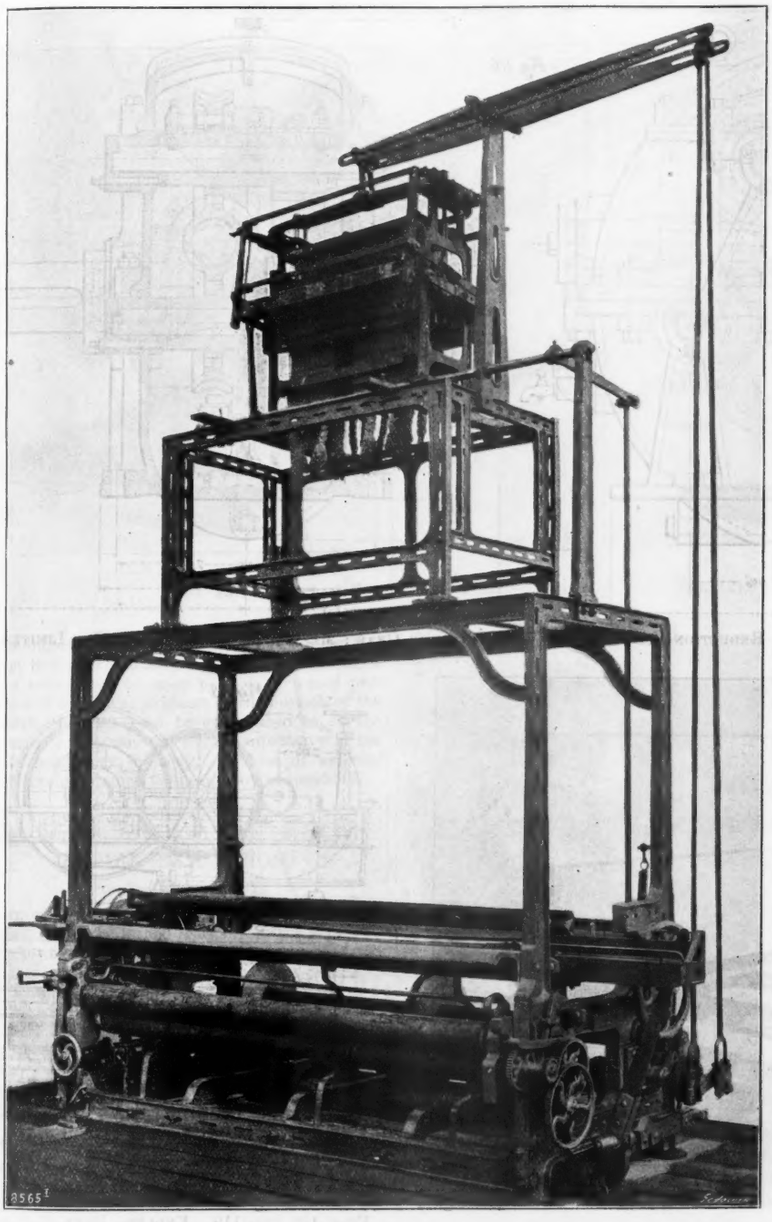


Fig. 34. Overpick Loom with Jacquard; Messrs. Atherton Brothers, Limited, Preston.

works, Burnley, is exhibited in use, in association with the same firm's Terry motion (Fig. 28) on an ordinary Lancashire loom making towels. The pattern for the body of the towel is carried on one barrel and the pattern for the border on the other. Either can be put into action at will. A special feature of the Climax dobbie is the method of constructing the working joints of the levers. In each of these the holes are coned, to give a large bearing surface and to ensure that the pull on the levers is always perfectly centred. The castings of the parts subjected to wear are chilled to give a dead hard surface with a smooth finish. All the mild steel shafts and studs are provided with cast-iron bushes to increase durability. The jack shafts are lubricated by grease cups. Each shaft is drilled longitudinally through its axis, and a hole cut radially through it communicates with a groove along which the lubricant is conveyed to each jack bearing. A semi-solid lubricant is used to avoid the risk of dirty oil dropping on the warp beneath.

In some types of textiles, such as towelling, an extra warp is introduced, and it is at periods fed forward to form loops on the surface of the fabric. To deal with this a mechanism known as a Terry motion is incorporated in the loom. By it the new warp threads are drawn in, and then they are bound into place in the fabric by the weft threads. The Stott and Smith Terry motion, made by Messrs. Lupton and Place, Limited, is a standardised motion which can be adapted to practically every design of loom. As sent out for the purpose of converting a loom for towel manufacture by the makers, the Terry box C (Fig. 28) only needs bolting by the brackets O, O to the loom side D, while the brackets M may be bolted in suitable positions on the stay swords P. As the brackets M with their shafts and the levers K and J are all set up before leaving the works, the only work necessary for the fitting of this part of the mechanism is the cutting away of the stay Q to make room for the reed case L and the connection by means of a leather band H to the hook B. The movement of the screw passing through the lock nut G regulates the length of the pile of the towelling.

In Fig. 29, Plate XXIII, an illustration is given of the Nelson dobby made by Messrs. James Hill and Son (Keighley), Limited, of Beechcliffe Dobby Works and Foundry, Keighley. In the Exhibition this dobby is fitted to a plain loom made by Messrs. John Pilling and Sons, Limited, of Colne, and is used to weave a fabric of the fine zephyr type containing a waved stripe of artificial silk. In this work only twelve of the sixteen stakes are put to use, and of them eight deal with the silk and four with the ground material. In this make of dobby the inside and outside heald lifting levers are operated independently of each other, teeth and knuckle joints being dispensed with. The baulks are strengthened and provided with radius pieces on each side of the centre, which prevents them, when in operation, from drawing clear and interlocking with each other. They are made to hook on to the bell levers in a way that gives a joint with the surface exposed to wear of the full pitch or width of the lever and baulk. The bottom needle and catch grate are made so that they can be removed and replaced without removing the feelers. A detachable drop tin is provided beneath the working parts of the dobby to prevent oil dropping on the work. All the working parts of the machine are provided with cast bushes.

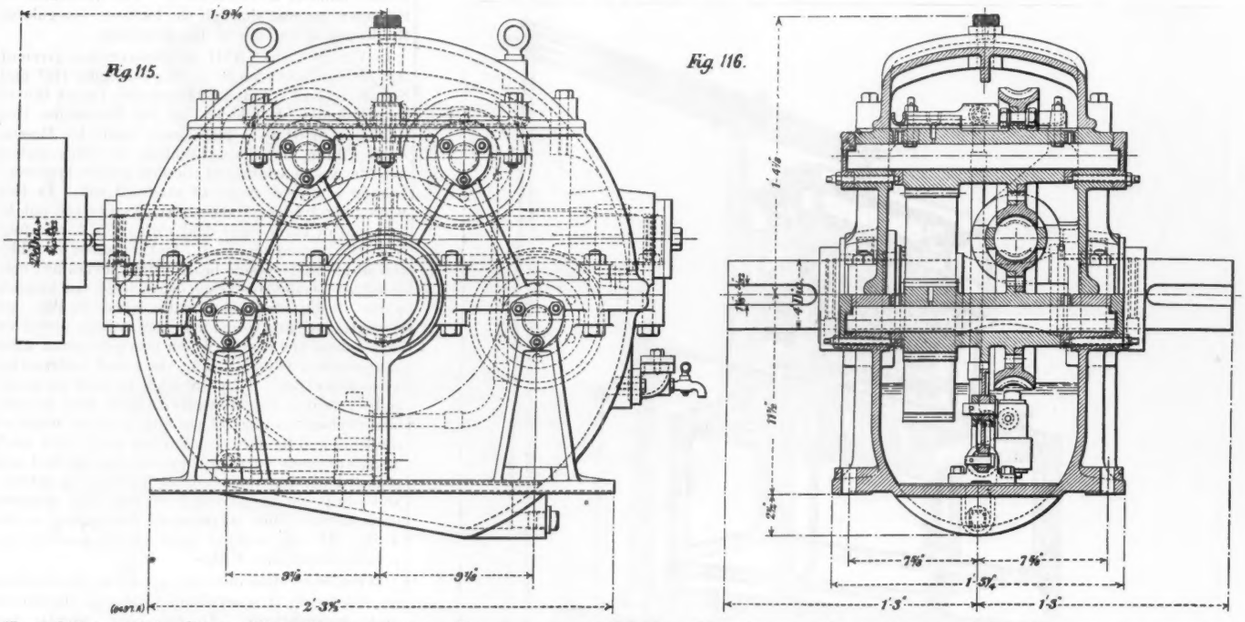
When more than one weft is used in the building up of a fabric, it is necessary to change the shuttle quite automatically. In this case, circular box looms are used. They are generally arranged to take six shuttles, and are made so that motion can be given to turn the box and bring another shuttle into position to be thrown through the shedding. A loom for weaving fancy dress goods made by Messrs. W. B. White and Sons, Limited, of Red Scar Loom Works, Colne, is shown in Fig. 30, Plate XXIII. This has a 44-inch reed space and is a six-shuttle revolving circular-box type of loom. It has many of the latest improvements such as a new type of pig wheel and T hammer, which ensure easy turning of the circular box, and take the strain off the pulling rods and the bottom levers. The bearings for the pulling rods and the back catches are of the cast-iron bolt joint type, which enable the correct pull to be given for the turning of the circular box. The dobby on the machine is of the open shed Streamer type, with sixteen shafts and double lift. In it large chilled bearings are used for all parts, while adjustment and dismantling are easy. The main driving shaft is provided with cast-iron bushes, and the levers on it are both keyed and secured by set screws. The feelers are held in their proper position by means of cast-iron guide grates at each end, which prevents wrong lifts and wasted work.

A folding machine for the finished material is shown in Fig. 31, on Plate XXIV, which will be referred to at the conclusion of the article. Fig. 32 shows another example of a circular box type of loom, made by Messrs. David Sowden and Sons, Limited, of Shipley, Yorkshire. This has a reed space of 42 in., and is provided with a six-shuttle circular box on one side and has a two-cylinder cord-reducing motion, so that it can be used for weaving work of any desired width with borders at each side. By the use of the two-cylinder cord motion, with one for the general body of the fabric, and the other for the two borders, a saving in the number of cords required is obtained. It can be fitted with a dobby if necessary.

With a Jacquard machine a large number of warp threads may be operated separately, and consequently, larger figures of patterns may be produced by its use than by the other mechanisms. The fundamental principle is that each thread is connected to a separate hook. These hooked wires are supported in a series of loops or eyes on a number of cross wires provided with springs at the one end and pointed at the other. These points pass through a needle board at the end of the machine. Motion for the liberation of the hooks from the griffe above, which normally holds them, is given from a series

UNDERGROUND HAULAGE GEAR AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see opposite page.*)



Figs. 115 and 116. Spence-Wild Worm and Spur Reduction for Main and Tail Haulage Gear; Messrs. M. B. Wild and Co., Limited.

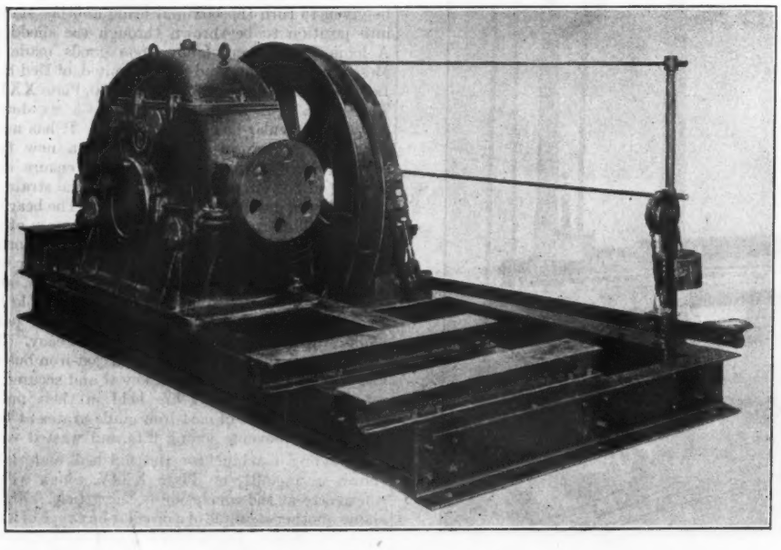
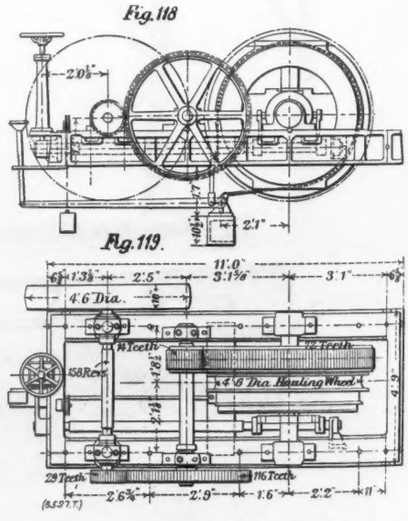


Fig. 117. Main and Tail Haulage Gear; Messrs. M. B. Wild and Co., Limited.



Figs. 118 and 119. Endless Rope Haulage Gear; Messrs. Markham and Co., Limited.

of perforated cards. Whatever cross wire is in line with a hole in the card passes into it and the hook it is associated with is unaffected. Those cross wires, which are not in line with the holes, are pressed to move against the action of the spring, and are rebased from the griffe. The griffe then rises carrying with it the undisturbed hooks and making a shed on the warp threads. When the shuttle is threaded through the shed the griffe descends and the next punctured cord is brought against the ends of the cross wires. By the use of this arrangement intricate and extensive patterns can be woven with considerable speed.

A Jacquard machine made by Messrs. Richardson, Tuer and Company, Limited, of Hope Foundry, Farnworth, is illustrated in Fig. 33. This Jacquard which is of the double-knife type, is fitted to an overpick power loom, made by Messrs. Atherton Brothers, Limited, of Hanover-street Foundry, Preston, which is shown in Fig. 34, page 249. The loom is of the high-speed loose-reed type, and the model in the Exhibition is driven by a special loom motor made by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. This loom is suitable for the weaving of all descriptions of fancy clothes up to the finest counts in both silk and cotton. In the work it is doing under the control of Messrs. Hollas, Limited, of Bolton, at the Exhibition, a cloth of an Empire design is being produced. This design was the successful one in a competition arranged by the firm, and was the work of a student of the Manchester School of Art.

The machine shown in Fig. 31, Plate XXIV, is a very good example of folding and measuring equipment. It is a product of Messrs. Hacking and Co., Limited, California Iron Works, Bury. The table of this machine is concave in contrast with the common convex design. It is made in two parts which incline inwards to give the concave shape, and the degree of rise they have may be varied to suit the texture of the cloth to be folded. The knives of the machine move horizontally and take the cloth in a straight line across the table from grip rail to grip rail, each fold being held under the grip rail until the succeeding fold is laid, when they fall successively into the cavity of the table. Each fold is, therefore, measured and laid independently on the other folds, and it may be said that the concave form of the table has no effect upon the accurate lengths of the folds. If thought advisable for any class of work, the table can be made practically a flat surface. Adjustment is provided to make any length of fold between 18 and 42 in.

Marked progress is shown in the development of cotton textile machinery for every specific purpose

ELECTRIC PUTTER AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. MAVOR AND COULSON, LIMITED, ENGINEERS, GLASGOW.

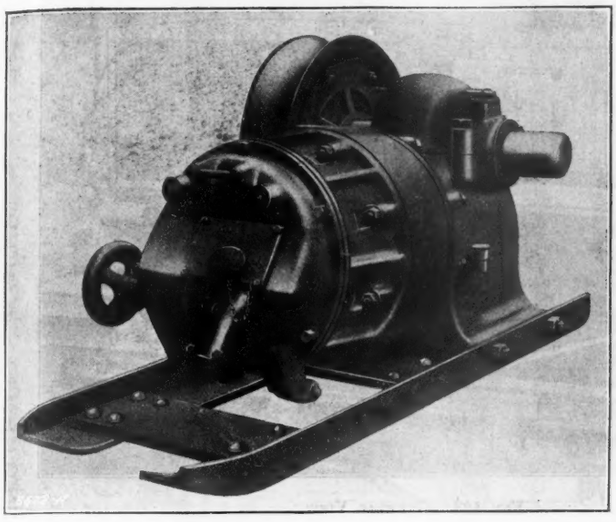


FIG. 120. GENERAL VIEW.

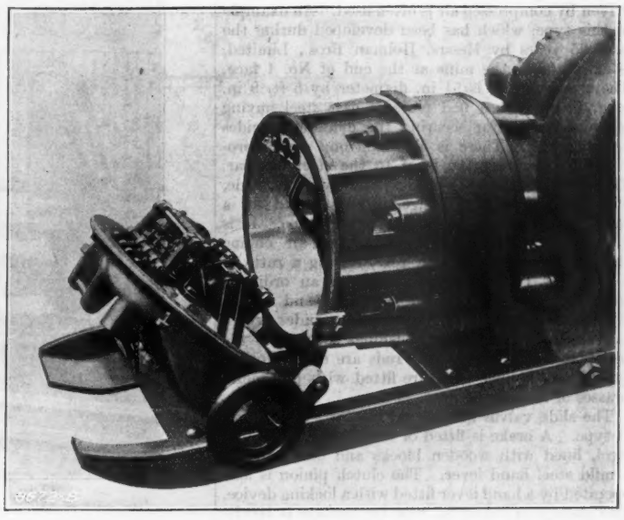


FIG. 121. VIEW WITH COVER OPEN SHOWING SWITCH.

in the industry, by the exhibits in the Cotton Mill of the Palace of Industry. With such indications of the endeavours to make possible increased production of textiles as evidence of the outlook of the industry, no fears need be entertained as to the continued maintenance of British supremacy in the textile machinery industry, a phase of activity which means so much to the welfare of mankind.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 227.)

THE problem of traction underground deals with the haulage of the loaded trucks from the loader to the pit, and with the return of the empty tubs to the face. The tubs according to circumstances, may require to be handled as trains consisting of a number coupled together, and this may occur either on the level or on moderate gradients; or they may require to be hauled individually up steep brows or inclines. To deal with the various problems that arise in this work, apart from pony haulage and manual handling, five types of haulage are to be seen either at work in the mine, or in the Palace of Engineering. These are (1) main and tail haulage for dealing with trains of full or empty tubs and their handling in the main galleries; (2) continuous haulage by endless rope, to which the tubs can be clipped by means of a disengaging clip and hauled for comparatively short distances; (3) stretcher bar haulage, in which a small winch driven by a compressed air engine or electric motor can be brought into action to pull loaded tubs successively up steep gradients to the main gallery; (4) the electric putter designed to assist in effecting the haulage between the advancing coal face and the auxiliary haulage, and (5) the electric locomotive fitted with accumulator batteries and capable of running through the workings and hauling or pushing a train of tubs.

A 25-h.p. main and tail electric haulage gear, (Fig. 117 on page 250), has been installed in the colliery by Messrs. M. B. Wild and Co., Limited, of Birmingham, and is fitted with the Spence-Wild worm and spur reduction gear-box, Figs. 115 and 116. The gearbox and motor are mounted on a composite bed constructed of rolled joist and channel sections, bolted together. The drums have mild steel sides and cast-iron rolls 2 ft. 6 in. diameter and are 1 ft. 6 in. between the flanges, which are 9 in. deep. A brake ring is bolted to each side

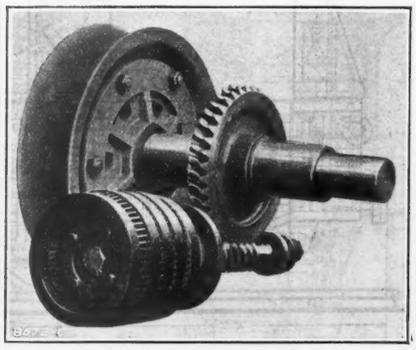


FIG. 122. ROTOR AND GEAR DRIVE.

of the drum to receive the brake straps. The drum bosses are of cast iron of the through type, fitted with roller bearings to suit the drum shaft, which is 5 in. diameter. The brake straps are of the all-round band reversible type, consisting of mild-steel straps lined with "Ferodo," operated by hand levers, conveniently arranged for the attendant. The clutches are of the external friction-band reversible type, consisting of a mild-steel strap, also lined with "Ferodo," carried on and driven by a semi-steel driver keyed to the drum shaft. The clutches are operated by means of hand wheels and screws through shafts and levers. The drum shaft is of mild steel, keywayed for the spur wheel, and arranged for the drums to run free on the roller bearings when not engaged with the clutches.

The outer end of the shaft is turned and fitted with roller bearings in a plummer block, the other end being carried in the gear reduction box. The motor is of the squirrel-cage type constructed by the General Electric Co., Ltd., of Witton, of 25 b.h.p., 50 cycles, three-phase, 440 volts, with star-delta oil immersed switch, mounted on the bed and transmitting power to the reduction gear through a flexible coupling of the pin and leather washer type. The motor is started up light and the load taken up by means of the friction-band clutch.

The Spence-Wild worm reduction gear consists of an arrangement of two worms with right and left-hand threads carried on the same shaft. The worm shaft is driven from the motor through the flexible coupling, and each worm gears with a worm wheel, the one being arranged above and the other below the shaft. As the worm wheels are of the same diameter and the worms of the same pitch, the duplex arrangement ensures balance without the use of a thrust block. Each worm wheel carries a mild-steel pinion, and as the wheels revolve in the same direction, these pinions can engage with the same spur wheel, each taking its share of the drive. The gearcase carries the roller bearing for the end of the drum shaft. The case is fitted with a drain plug and inspection door. The mean rope speed is about four miles per hour with the motor running at 720 r.p.m.

At the foot of the upcast shaft there is installed an endless rope haulage gear, Figs. 118 and 119, on page 250, constructed by Messrs. Markham and Co., Limited, of Chesterfield. The gear consists of a hauling wheel 4 ft. 6 in. diameter of cast iron, fitted with chilled cast-iron renewable treads. It is driven by a 30-h.p. Brook three-phase motor, running at 720 r.p.m. and driving the first motion shaft, fitted with a 4-ft. 6-in. pulley, at 158 r.p.m., by means of a 9-in. belt. The drive is effected through a double reduction gear in which the steel pinion and the cast-iron wheel have machine-cut teeth for the first reduction. The second motion gearing is of cast iron, both pinion and wheel having machine-moulded teeth shrouded to the pitch line. The controls are: a clutch of the internal ring friction type, operated by means of a handwheel mounted on a vertical pillar, and the brake of the all-round band, Ferodo-lined, type applied by a foot lever. The whole of the gear and the controls are rigidly carried on a strong cast-iron frame. The gear is designed to give a rope speed of $1\frac{1}{4}$ m.p.h.

A very compact portable haulage gear arranged on a base which can be bolted down to timbers, is also made by Messrs. Markham and Co. This has a haulage drum, placed centrally between two A frames and carrying a gear wheel on one side; the driving pinion engaging with the gear wheel is carried on a shaft, which is fitted with disc cranks at each end, and revolves in bearings carried on the tops of the A frames. The two cylinders of the engine are arranged one on each side, and are made either with or without reversing gear. The brake is controlled by a foot treadle, which is the only part that overhangs the base. The size of the smallest of these appliances is such that it can go inside an ordinary pit tub, and thus save time in being transferred from place to place. The engine has cylinders $4\frac{1}{2}$ in. bore by 5 in. stroke;

the drum is capable of holding 600 yards of ⅜-in. diameter rope, and when supplied with air at 80 lb. per square inch can give an actual rope pull of 1,150 lb.

For hauling tubs up steep brows or out of difficult places, a portable stretcher bar mounted hoist driven by compressed air is often used. An example of this type, which has been developed during the past 25 years by Messrs. Holman Bros., Limited, is exhibited in the mine at the end of No. 4 face. The stretcher bar is 5½ in. diameter by 5 ft. 9 in. long, fitted with a bed plate of cast steel having machined faces for securing the cylinders, guides and bearings. There is also a strong clamp provided for securing the hoist to the stretcher bar. The drum, which is 7½ in. diameter by 9½ in. wide, with 3½ in. depth of flange, is constructed for a capacity of 500 ft. of ⅜ in. diameter rope. It is driven by a two-cylinder compressed-air engine through a single reduction gear, having a ratio of 4·9 to 1. The engine is similar to an ordinary steam engine, with cast iron pistons and Ramsbottom cast iron spring rings. The guides are of cast steel with gun-metal bushings secured to the bed plate. The connecting rods are of the forked type, and the big ends are fitted with gun-metal brasses of the marine type.

The slide valves are of cast-iron of the ordinary D type. A brake is fitted of the band type of mild steel, lined with wooden blocks and connected to a mild steel hand lever. The clutch pinion is also operated by a hand lever fitted with a locking device. The average speed of the rope for haulage is 100 ft. per minute, or 1·1 miles per hour. The gear is capable of lifting a gross load of 2,600 lb. vertically, or hauling a gross load of 5,000 lb. up to a 30 deg. gradient.

The electric putter, Figs. 120 to 122 on page 251, manufactured by Messrs. Mavor and Coulson, forms a simple and compact haulage gear of 8 to 10 h.p. suitable for dealing with the tub traffic between the face and the auxiliary haulage. The structural portion that forms the body of the machine is the casing for the worm gear, and to it are attached the cover of the gearcase, the stator of the motor, and the switch case with its cover. The putter is mounted between the angle iron frames of a sledge to which it is secured by bolts; the projection of the sledge beyond the structure affords a base for the props that secure the putter in position. The working parts and the rotor, which is of the squirrel cage type, are shown in the detail view, Fig. 122. The worm-shaft is carried on two radial ball bearings, and a thrust ball bearing is mounted on the end of the shaft, the rotor being overhung. The main shaft carries the worm wheel, which has a phosphor-bronze rim carried on a cast-iron centre. The main bearings are bushed.

The pulley of cast steel is adapted for reversing endless haulage, and may be mounted on either side of the putter. As the shaft projects on both sides of the main bearings, two drums may be fitted if required for main and tail haulage. The switch, of the reversing type and barrel construction, Fig. 121, is attached to the inside of the hinged end cover, and is accommodated in the casing when in place with the cover closed. When the cover is opened there is complete access to the switch. The socket to receive the trailing cable pommel is incorporated in the switch cover. A very compact form of electric putter is also exhibited by the Diamond Coal Cutter Company in the Palace of Engineering.

The electric locomotive exhibited and illustrated in Figs. 123 to 125 on this page, is a No. 2, 10-ton haulage capacity, electric locomotive 2 ft. gauge, constructed by Joseph Booth and Bros., Limited, of Rodley. The total weight is approximately 3 tons, wheel diameter 16 in., and tractive effort 300 lb. approximately. The length over buffers is 7 ft. 6½ in. The batteries consist of 24 cells, the normal charging current being 32 amperes, and the normal discharge voltage 48 volts. The capacity at one-hour rate is 126 amperes; at three-hour rate, 60 amperes; and at six-hour rate, 30 amperes. There is one motor of 3 brake horse-power rating, and the speed of the locomotive at the specified load and discharge at the three-hour rating, is 3 miles per hour; the motor is capable of giving 6½ brake horse-power. There is a totally enclosed worm drive to each axle with free coasting gear, the worms being carried in ball bearings at each end, with a double thrust ball bearing completely housed in an oil bath. Connection between the two worms is by means of a shaft and universal joints. The axles run in large ball bearings fitted with caps to exclude dirt and retain the oil, and the axle-boxes carry the load through involute springs. The wheels are of chilled cast iron, keyed to the axles. A heavy shield casting is mounted at each end of the frame to protect the battery and electrical gear from damage. The head lamps are recessed into these as a protection. There are spring buffer plates at each end, to allow the trucks to be pushed round curves. The towing hook is provided with an involute spring to ease the starting, and has a locking clip to prevent the towing links from becoming detached. The towing hook is also made suitable for towing trucks round curves. The controller is of the drum type, totally enclosed, with hinged spring-controlled fingers, manufactured by the Electro Mechanical Brake Company. There are three speeds forwards and backwards and a screw-down brake operating on all four wheels with an equaliser to distribute the pressure uniformally over the wheels. The shoes are lined with Ferodo. A large, deep-toned gong is fitted for giving warning.

(To be continued.)

ELECTRIC COLLIERY LOCOMOTIVE.

CONSTRUCTED BY MESSRS. JOSEPH BOOTH AND BROTHERS, LTD., ENGINEERS, RODLEY.

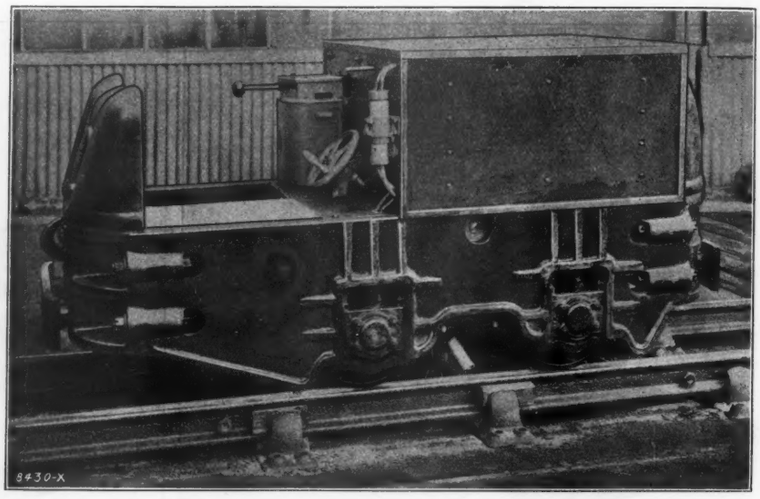
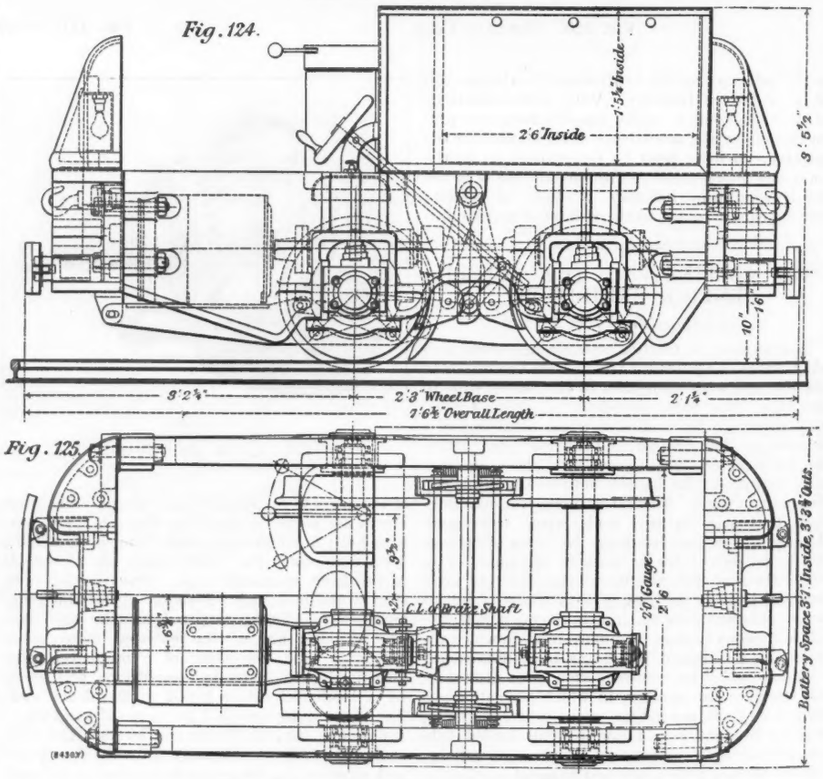


Fig. 123. General View.



Figs. 124 and 125. Elevation and Plan.

Battery Space 3'7" Inside, 3'3½" Outs. 3'5½"

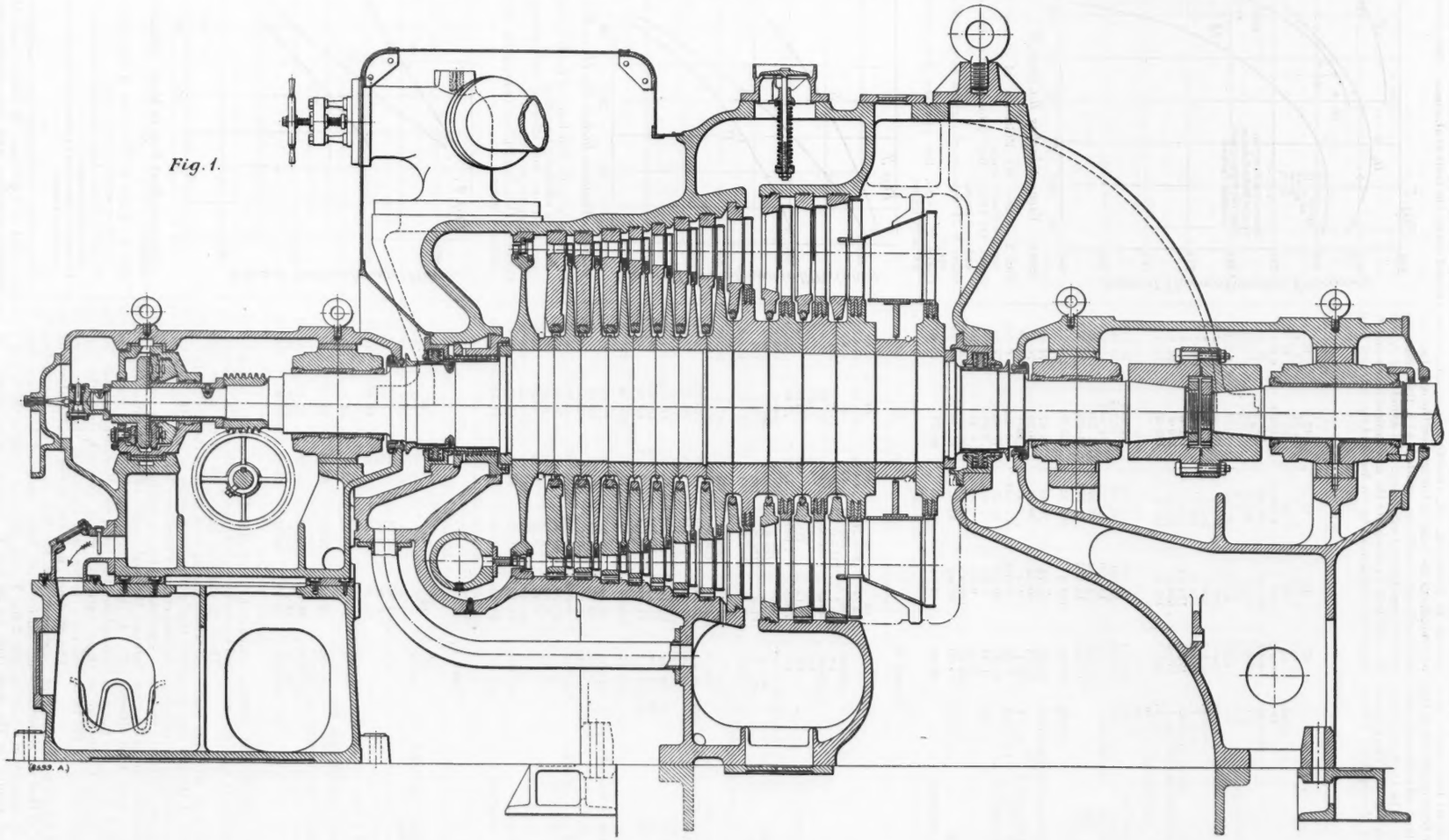
DLEY.

24.

7,000-KW. STEAM TURBINE AT THE BRISTOL ELECTRICITY WORKS.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

Fig. 1.



TESTS OF A 7,000-KW. STEAM TURBINE GENERATOR AT THE BRISTOL ELECTRICITY WORKS.

NOT very many exhaustive tests have been made on steam turbines, and of these only a few have been published. In general, moreover, where the test figures have been most complete, detailed particulars of the turbine have been lacking, and, alternatively, where these details have been provided the test figures published have been far from comprehensive. We welcome accordingly the report which we reproduce below on some very exhaustive tests of a 7,000-kw. machine at Bristol, which have been carried out with extreme care by the Metropolitan-Vickers Electrical Company, Limited, of Trafford Park, Manchester. The main object of the test was to establish by actual figures the real efficiency of the multiple exhaust arrangement, which is now embodied in all the large turbines constructed by the firm in question.

To this end, the machine was tested first without the last rows of blading, so that it operated on the ordinary single-exhaust principal. The multiple exhaust rows were then put in place and new tests made. In order to ensure that the results should be truly comparable the same instruments were used throughout the tests, and the observations were made by the same staff on both tests. It will be seen from the report published below, which has been drawn up by Mr. K. Baumann, that the multiple exhaust proved highly satisfactory. The thanks of the profession are due to Mr. Faraday Proctor, the electrical engineer to the Bristol Corporation, for the facilities provided for this interesting test, and to the makers for the completeness of the figures published.

The following is Mr. Baumann's report :—

In order to demonstrate the efficiency of the multi-exhaust blading a number of interesting tests were carried out on a 3,000 r.p.m. turbine rated at 7,000 kw. This turbine is installed at the Feeder Road Station of the Bristol Corporation Electricity Department. The manufacturers are indebted to Mr. Faraday Proctor,

the Chief Engineer and General Manager, and to his deputy, Mr. Newman, for the facilities and assistance given to enable them to carry out these tests with the care that is necessary. The official test results have recently been published, and the tests dealt with in this report were made before the final adjustments were carried out for the official tests. The type of turbine is shown on the section drawing, Fig. 1. The exhaust end of this turbine includes the Metropolitan-Vickers Electrical Company, Limited, multi-exhaust blading and embraces the latest arrangements with a view to improving the steam flow.

The first series of tests was made with the multi-exhaust blading, which consists of the last two rows of moving blades and the co-operating diaphragms, removed. During the second series of tests the turbine was complete with the blading as shown in the drawing. Each series consisted of tests made with different vacua. In the case of the first series the range of vacua was between 26·114 in. and 28·471 in. and for the second series the vacua varied from 27·594 in. to 29·034 in.

The initial steam conditions for all tests were kept as nearly as possible constant, so that the corrections to be applied for the purpose of comparison would be as small as possible. The test results for the first series of tests are given in Table A and for the second series of tests in Table B.

With the addition of the multi-exhaust blading a larger output can be obtained with the same inlet conditions; hence, the mechanical efficiency of the turbine is increased. If, therefore, the comparison were made on the basis of the load on the coupling the multi-exhaust would be credited with this improvement in mechanical efficiency. To avoid this it was thought best to eliminate the mechanical losses and to make the comparison on the basis of the internal load which is the external load on the coupling plus mechanical losses due to bearings, paddle wheels, oil pump, &c. These mechanical losses are given under item 7, allowance having been made in their estimate for the fact that during both series of tests the bearing and oil temperatures were very low.

The internal load is tabulated under item 8, and the internal thermodynamic efficiency ratio under item 23. As the steam pressure was very nearly constant throughout the tests, no allowance is made for the slight variation which occurred, since the internal efficiency varies very little with the steam pressure. The efficiency, however, varies considerably with the superheat, and for this reason the thermodynamic efficiencies have been corrected to a superheat of 180·2 deg. F., the allowance being at the rate of 1 per cent. for 50 deg. F. difference in superheat. As the actual correction is very small (in fact not more than plus or minus 0·4 per cent.) this method of applying the correction is sufficiently accurate. The efficiencies thus corrected are given under item 26, Tables A and B and are plotted in Fig. 2 as ordinates with the vacua obtained during the tests as abscissæ. (See curves M & N).

TABLE A.

1	Test No.	43	44	45	42	41
2	Date	3.4.24	3.4.24	3.4.24	3.4.24	3.4.24
3	Duration of test ... mins.	63	63	63	63	63
4	Corrected load on generator ... kw.	5,912·2	5,999·2	6,250·0	6,615·6	6,834·2
5	Test efficiency of generator ... per cent.	94·04	94·08	94·20	94·35	94·44
6	Load at turbine coupling ... kw.	6,287	6,377	6,635	7,012	7,236
7	Bearing, paddle and governor losses ... kw.	115	115	115	115	115
8	Internal load ... kw.	6,402	6,492	6,750	7,127	7,351
9	Steam pressure at stop valve ... lbs./sq. in. gauge	190·6	190·2	193·0	193·5	193·2
10	,, temperature ,, ,, ... deg. F.	575·3	558·2	565·1	579·6	574·8
11	,, superheat ,, ,, ... deg. F.	191·2	174·3	180·1	194·4	189·7
12	,, pressure after gov. valve ... lbs./sq. in. gauge	173·3	173·25	175·3	181·6	181·6
13	,, temperature ,, ,, (assumed as (10)) deg. F.	575·3	558·2	565·1	579·6	574·8
14	,, superheat ,, ,, ... deg. F.	198·6	181·6	187·6	199·3	194·5
15	,, pressure in front of multi-exhaust (30 in. bar) ... in. hg.	—	—	—	—	—
16	Vacuum at turbine exhaust (30 in. bar) ... in. hg.	26·114	26·595	27·066	27·445	28·471
17	Total steam consumption per hour ... lbs.	78,830	79,609	80,139	82,355	83,195
18	Steam consumption referred to (4) lbs./kw.-hour.	13·333	13·270	12·822	12·449	12·173
19	,, ,, ,, (6) ,,	12·539	12·485	12·078	11·744	11·497
20	,, ,, ,, (8) ,,	12·313	12·262	11·872	11·555	11·317
21	$i_{12}\left(\frac{12}{14}\right) - (16)$ ... cal/kg.	190·63	192·3	198·13	205·10	219·23
22	Thermodynamic efficiency of turbine ref. to (6) per cent.	79·07	78·72	78·98	78·47	74·99
23	,, ,, ,, ,, (8) ,,	80·52	80·15	80·35	79·75	76·17
24	Difference in superheat from 180·2 deg. F... deg. F.	+18·4	+1·4	+7·4	+19·1	+14·3
25	Superheat. correction (50 deg. F. = 1 per cent.) per cent.	−0·368	−0·028	−0·148	−0·382	−0·286
26	(23) Corrected to 180·2 deg. F. superheat. ... ,,	80·22	80·13	80·23	79·45	75·95
27	Leaving loss ... cal/kg.	1·44	1·93	2·67	3·68	9·03
28	Exhaust loss ... ,,	0·16	0·22	0·30	0·42	1·02
29	Net i_{12} ... ,,	189·03	190·15	195·16	201·0	209·18
30	Corresponding η_t referred to (8) ... per cent.	81·20	81·06	81·57	81·38	79·83
31	(30) Corrected to 180·2 deg. F. superheat ... ,,	80·90	81·04	81·45	81·07	79·60

TABLE B.

1	Test No.	66	65	60	64	63
2	Date	15.4.24	15.4.24	14.4.24	15.4.24	15.4.24
3	Duration of test ... mins.	59½	59½	63	63	63
4	Corrected load on generator ... kw.	6883·7	7114·6	7268·0	7259·0	7321·0
5	Test efficiency of generator ... per cent.	94·45	94·55	94·60	94·60	94·62
6	Load at turbine coupling ... kw.	7,288	7,525	7,683	7,673	7,737
7	Bearing, paddle and governor losses ... kw.	115	115	115	115	115
8	Internal load ... kw.	7,403	7,640	7,798	7,788	7,852
9	Steam pressure at stop valve ... lbs./sq. in gauge	190·8	193·0	197·3	189·9	189·8
10	,, temperature at stop valve ... deg. F.	565·8	563·2	550·1	567·3	568·4
11	,, superheat at stop valve ... deg. F.	181·6	178·2	163·3	183·5	184·7
12	,, pressure after governor valve ... lbs./sq. in gauge	187·4	189·0	188·6	185·9	184·8
13	,, temperature after governor valve (assumed as (10)) deg. F.	565·8	563·2	550·1	567·3	568·4
14	,, superheat after governor valve ... deg. F	183·1	179·8	166·9	185·2	186·8
15	,, pressure in front of multi-exhaust (30-in. bar) in. hg.	26·351	26·449	26·585	26·628	26·658
16	Vacuum at turbine exhaust (30-in. bar) ... in. hg.	27·594	27·972	28·587	28·706	29·034
17	Total steam consumption per hour ... lbs.	83,952	85,351	85,594	83,858	83,644
18	Steam consumption referred to (4) ... lbs./kw.-hr.	12·196	11·997	11·777	11·552	11·425
19	,, ,, ,, (6) ... lbs./kw.-hr.	11·519	11·342	11·140	10·929	10·811
20	,, ,, ,, (8) ... lbs./kw.-hr.	11·340	11·171	10·976	10·767	10·652
21	$i_{12}\left(\frac{12}{14}\right) - (16)$ ... cal./kg.	205·89	210·72	219·00	223·33	231·28
22	Thermodynamic efficiency of turbine referred to (6) per cent.	79·69	79·08	77·46	77·43	75·59
23	,, ,, ,, ,, (8) ,,	80·95	80·29	78·62	78·59	76·71
24	Difference in superheat from 180·2 deg. F... deg. F.	+2·9	−0·4	−13·3	+5·0	+6·6
25	Superheat correction (50 deg. F. = 1 per cent.) ... per cent.	−0·058	+0·008	+0·266	−0·100	−0·132
26	(23) Corrected to 180·2 deg. F. superheat ... ,,	80·90	80·30	78·83	78·51	76·61
27	Leaving loss ... cal./kg.	1·92	2·64	4·96	5·68	9·52
28	Exhaust loss ... ,,	0·48	0·66	1·24	1·42	2·38
29	Net i_{12} ... ,,	203·49	207·42	212·8	216·23	219·38
30	Corresponding η_t referred to (8) ... per cent.	81·90	81·57	80·91	81·18	80·87
31	(30) Corrected to 180·2 deg. F. superheat ... ,,	81·85	81·58	81·12	81·10½	80·76

TABLE C.

	Test No.	66	65	60	64	63
1	Energy in steam leaving the stage prior to M.E. ... cal./kg.	2·2	2·2	2·2	2·2	2·2
2	Adiabatic heat drop in M.E. stage ... ,,	14·3	17·3	27·6	29·8	38·5
3	Leaving loss ... ,,	1·92	2·64	4·96	5·68	9·52
4	Exhaust loss ... ,,	0·48	0·66	1·24	1·42	2·38
5	Work done in M.E. stage ... ,,	11·50	13·04	17·29	18·05	19·45
6	"Net available heat drop" M.E. stage = (1) + (2) − (3) − (4) cal./kg.	14·1	16·2	23·6	24·9	28·8
7	Efficiency of M.E. stage using adiabatic heat drop = (5)/(2) per cent.	80·42	75·38	62·64	60·57	50·52
8	Efficiency of M.E. stage using "net available heat drop" = (5)/(6) ... per cent.	81·56	80·49	73·26	72·49	67·54
9	(1) − (2) ... cal./kg.	16·5	19·5	29·8	32·0	40·7
10	Efficiency = (5)/(9) ... per cent.	69·70	66·87	58·02	56·41	47·79

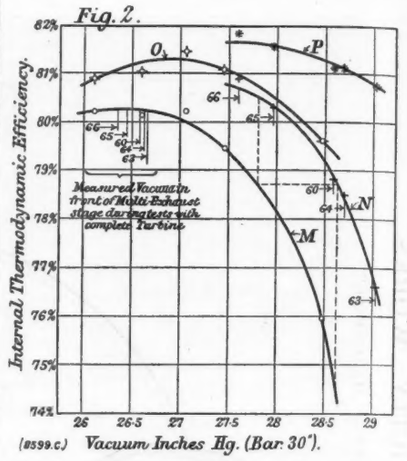


FIG. 2.—Curve M: Efficiency of turbine without multi-exhaust stage.
Curve O: Ditto, but allowing for leaving and exhaust losses.
Curve N: Efficiency of turbine with multi-exhaust stage.
Curve P: Ditto, but allowing for leaving and exhaust losses.

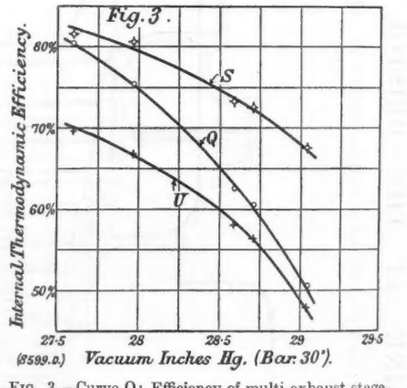


FIG. 3.—Curve Q: Efficiency of multi-exhaust stage based on adiabatic heat drop.
Curve U: Ditto, but allowing for carry-over from preceding stage.
Curve S: Ditto (as U), but allowing for leaving and exhaust losses.

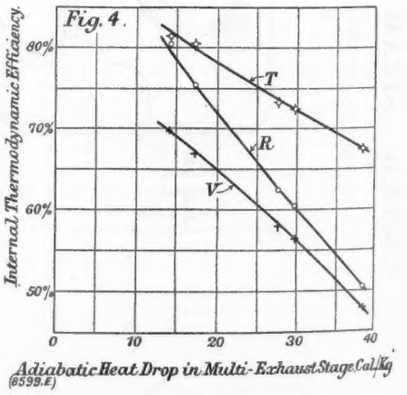


FIG. 4.—Curve R: Efficiency of multi-exhaust stage based on adiabatic heat drop.
Curve V: Ditto, but allowing for carry-over from preceding stage.
Curve T: Ditto (as V), but allowing for leaving and exhaust losses.

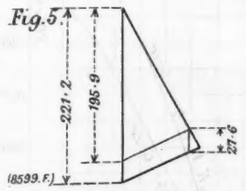
The turbine was designed for a vacuum of 28·63 in. at a load of 7,000 kw. At this vacuum the internal efficiency obtained with the complete machine was 78·7 per cent. At the same vacuum the efficience obtained without multi-exhaust blading was only

74·4 per cent., the difference in steam consumption being 5·6 per cent. On the other hand, without the multi-exhaust blading an efficiency of 78·7 per cent. was obtained at a vacuum of 27·8 in. The addition of the multi-exhaust blading, therefore, enables a vacuum of 28·63 in. to be utilised with the same efficiency as a vacuum of 27·8 in. is used without the multi-exhaust blading. Again, the addition of multi-exhaust blading enables even this lower vacuum of 27·8 in. to be utilised more efficiently, an increase from 78·7 per cent. to 80·5 per cent. being obtained, as shown in Fig. 2.

During the whole of the tests under discussion the feed-water heater was not in operation, but the feed-heater space was connected by means of a large drain, 3 in. diameter, to the condenser, so that a considerable quantity of steam was bye-passed into the condenser. It is estimated that the steam quantity thus lost for useful work in the exhaust blading is approximately 1·8 per cent. of the total steam quantity, and the corresponding loss in output is, therefore, about 0·4 per cent. when the turbine is working as a complete machine at 28·63 in. vacuum. This loss in output is only 0·3 per cent. when the turbine is working without the multi-exhaust blading at a vacuum of 27·8 in. It should also be noted that during all the tests shown in Fig. 2, the turbine was insufficiently lagged; this results, of course, in a relatively smaller amount of work done in the low-pressure stages. During subsequent tests with the turbine completely lagged, the feed-heater drain reduced to reasonable proportions and the bearing temperatures brought up to standard practice, a considerably better result was obtained for the complete set than that obtained during these preliminary tests.

During the tests under discussion extreme care was taken to keep the conditions exactly similar for the whole series of tests. It should also be noted that

Fig. 5.



throughout all the tests the same instruments were used and the same observation staff, every care being taken to eliminate personal error.

Before the complete machine was tested, the main high-pressure gland was adjusted with a view to reducing the leakage losses. It is estimated that this effected an improvement in efficiency of the order of 0·2 per cent. This improvement obtained with the complete machine compensates approximately for the difference between the drain leakage and radiation losses obtained during the two series of tests, so that within the errors of testing and calculation, which are very small indeed, the two curves M and N give a true picture of the difference of efficiencies obtained with and without the multi-exhaust stage.

The efficiency curves M and N show clearly the relatively rapid decrease in efficiency at higher vacua, this being due to the increased leaving and exhaust losses. In all tests the vacuum was measured at the turbine exhaust flange in accordance with the makers' standard practice, and not as is done in some tests, immediately after the last row of blades and at the top of the exhaust. That the decrease in efficiency is mainly due to increased leaving and exhaust losses is shown by considering the efficiency on the basis of "net available heat drop," which is made up as follows:—

(1) The adiabatic heat drop based on inlet conditions and the vacuum at the exhaust flange.
(2) Minus the unavoidable leaving loss.
(3) Minus the exhaust loss.*

The leaving area and the exhaust area are given in Appendix I, which also shows an example of calculating the leaving and exhaust loss. For a given leaving blade area the leaving loss is a minimum when the leaving velocity is axial and item (2) has been calculated on this assumption.

The calculation of these efficiencies is given under items 27 to 31 of Tables A and B, and the results are plotted in curves O and P, Fig. 2.

It will be seen from Appendix I that the leaving area is 15·25 sq. ft., and it should be noted that to obtain the same area from a single row of moving blades with a ratio of mean diameter to blade height of 3·5, the mean diameter would have to be increased from 42 in. to 51 in., that is to say, it would be necessary to employ a blade 14½ in. long on a mean diameter of 51 in.

During the tests with the complete machine the pressure in front of the multi-exhaust stage was measured at a point in close proximity to the shrouding of the wheel preceding the multi-exhaust stage (see Fig. 6). These pressures are given in Table B, item 15, and are indicated on curve M. It is possible that the windage may have affected the reading to some extent, as from calculations one would estimate that the pressure should have been slightly higher. This difference, however, could be explained by the possibility of the steam being undercooled.

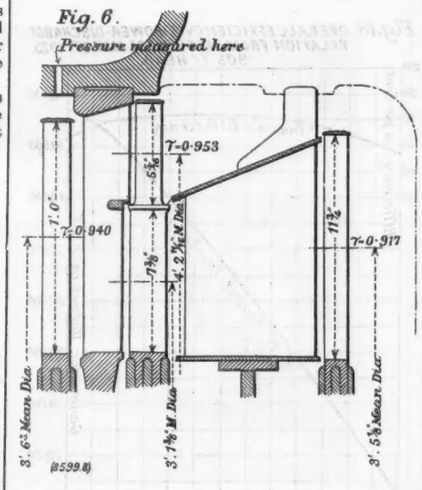
Knowing the pressure in front of the multi-exhaust blading it is possible to calculate the heat drop available for the multi-exhaust stage. We can also determine the efficiency with which this heat drop is utilised by making a comparison between:

(*a*) The result obtained with the complete turbine.

(*b*) The result obtained with the turbine without the multi-exhaust blading when exhausting to a vacuum which is the same as the vacuum in front of the multi-exhaust blading as measured in (*a*).

In calculating these efficiencies, corresponding points on curves M and N have been taken and the results

Fig. 6.



worked out on the basis of adiabatic heat drop, no allowance being made for the reduction of the adiabatic heat drop resulting from the undercooling of the steam (for an example, see Appendix II). The efficiencies thus obtained for the multi-exhaust stage are plotted against the vacuum in the exhaust (curve Q, Fig. 3) and against the adiabatic heat drop utilised in the multi-exhaust stage (curve R, Fig. 4).

It will be seen from the curves that as the vacuum is increased the efficiency of the multi-exhaust stage decreases, this being due to a large extent to the increase in leaving loss. In order to demonstrate this the efficiency of the multi-exhaust stage has been arrived at from the test results assuming that the energy available for use in the multi-exhaust stage is made up as follows:—

(1) The energy in the steam leaving the stage prior to the multi-exhaust.
(2) Plus the adiabatic heat drop corresponding to the expansion in the multi-exhaust stage.
(3) Minus the unavoidable leaving loss.
(4) Minus the unavoidable exhaust loss.

The calculation of the efficiencies using this "net available heat drop" is given in Table C, and the efficiencies are shown in curve S, Fig. 3, and curve T, Fig. 4.

The efficiency of the multi-exhaust stage has also been calculated on the basis of the available heat drop consisting of items 1 and 2, no allowance being made for leaving and exhaust losses. The efficiencies thus calculated are shown in curve U, Fig. 3 and curve V, Fig. 4.

The tests which have here been dealt with were made at a nominal load of 7,000 kw., which is the rating of the machine. Another series of tests was made at a nominal load of 80 per cent. of the above, the results of which are in accordance with the 7,000 kw. tests. The writer dealt exclusively with the tests at the larger load because in these tests more work, of course, is done in the exhaust end of the turbine.

These series of tests which have been carried out and investigated with great care indicate that the claims which have been made for the Metropolitan-Vickers multi-exhaust design have been fully established in actual practice.

* It is, of course, an open question whether or no items (2) and (3) should be added together to get the total losses. The procedure involves the assumption that the whole of the kinetic energy represented by (2) is dissipated as heat before the exhaust port is reached. The justification for this assumption is based on the experience of the builders, which shows that tests made under different conditions are more consistent with each other when corrected on this hypothesis.

APPENDIX I.

CALCULATION OF LEAVING AND EXHAUST LOSSES.

Complete Machine.

Axial leaving area = 15·25 sq. ft. (see Fig. 6).
Exhaust area = 30·6 sq. ft.

Machine without Multi-Exhaust Stage.

Axial leaving area = 10·31 sq. ft.
Exhaust area = 30·6 sq. ft.

As an example of calculating the L + E losses, take test No. 60.

$$\text{Axial leaving velocity} = \frac{85594 \times 428}{3609 \times 15{\cdot}25} = 668 \text{ ft. per sec.} = 204 \text{ metres per second.}$$

$$\text{Leaving loss} = \frac{(204)^2}{(91{\cdot}5)^2} = 4{\cdot}96 \text{ cal/kg.}$$

$$\text{Exhaust velocity} = \frac{85594 \times 428}{3600 \times 30{\cdot}6} = 333 \text{ ft. per sec.} = 102 \text{ metres per sec.}$$

$$\text{Exhaust loss} = \frac{(102,)^2}{91{\cdot}5^2} = 1{\cdot}24 \text{ cal./kg.}$$

APPENDIX II.

CALCULATION OF EFFICIENCY (η) OF MULTI-EXHAUST BLADING.

Example: Test 60.

(N.B.—Heat drops are taken from a Mollier chart—Stodola 5th edition).

Adiabatic heat drop for complete turbine from 188·6 lbs./sq. in. g. 180·2 degs. F. to 28·587" vac. = 221·2 cal/kg. (see Fig. 5).

Measured vacuum before multi-exhaust blading = 26·585" Hg.

Adiabatic heat drop from 188·6 lbs./sq. in. gauge 180·2 degs. F. to 26·585" vacuum = 195·9 cal/kg.

Adiabatic heat drop through multi-exhaust stage = 27·6 cal/kg.

Internal efficiency of complete turbine at 28·587" vac. = 78·89 per cent.

Internal efficiency of turbine without multi-exhaust blading at 26·585" vac. = 80·25 per cent.

Therefore, 221·2 × 78·89 = 195·9 × 80·25 + work done in multi-exhaust stage.

∴ Work done in multi-exhaust stage = 17·29 cal/kg.

Hence, efficiency of multi-exhaust stage, calculated on adiabatic heat drop $= \frac{17{\cdot}29}{27{\cdot}6} = 62{\cdot}6$ per cent.

QUEENSTON-CHIPPAWA DEVELOPMENT OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.*

By F. A. GABY.

(*Concluded from page* 223.)

GENERATING AND TRANSFORMER STATION.

THE generating and transformer station is situated below the escarpment and close to the river's edge (Fig. 15, Plate XX of last week); the station extends about half the distance to the top of the escarpment. The structure required to house ten main units and the service equipment is 700 ft. long. The substructure is of massive concrete construction carried down to rock foundations. The superstructure consists of a structural steel framework with reinforced concrete floors and roofs, and concrete, brick and tile walls and partitions.

The location of the transformer and switching part of the plant on the top of the escarpment was considered, but owing to the difficulties in transmitting the current at 12 kv. from the generators to the transformers up the cliff, and to the operating advantages in having a combined station, also to the space between the generator room and the cliff being sufficient for the purpose, it was decided to have the building to house the transformers and switching equipment combined with the generator room.

The steel columns are spaced longitudinally 26 ft. and 24 ft. alternately, starting at the south end. The strength of the generator room steel was primarily determined by the necessity of providing cranes to handle the generator rotors which weigh about 300 tons each. The structural steel was so designed that it could be erected and the crane operated before the concrete walls were poured.

To guard against flooding, the walls are designed to resist water pressure up to elevation 300, which is 16 ft. above the base of the generators. No openings

* Read before the Section G of the British Association at Toronto, August 8, 1924.

which might admit water from the river were permitted below this elevation.

Some additional features which may be mentioned are: the arrangement of the generator cooling air intake ducts, which are carried up in the east wall between the columns to above elevation 300, where openings are provided to admit air either from outdoors, or from the interior of the generator room, an arrangement which takes up no floor space; the location of the generator room main floor at the top of the generator frame, a construction which provides space at small cost for the exhaust air ducts, fans and generator field equipment adjacent to the unit, and allows a clear space around the generator on the main floor. The floor at the top of the generator frame materially reduces the unsupported height of the main crane columns, and does not affect the elevation of the crane rails, as the height of the crane is determined by the height of generator frame and shaft. The location of the control room is over the generator room at the centre of the completed plant; provision is made of separate rooms for each oil circuit breaker, and particularly for the symmetrical location of all main equipment for each unit—governors, transformers, oil circuit-breakers, reactors, fans—in the 50-ft. transverse space in which the turbine and its generator are situated.

Access to the building from the main roadway and to the electric railway on the top of the cliff is provided by the elevator in the administration end of the screen house, and a tunnel from the bottom of the elevator shaft to the power-house floor at elevation 346 at the south end (Fig. 8, page 222 *ante*).

In general, all plant services are provided in the southerly 75 ft. of the station. In this area are situated the sump pumps and motors, the air compressor, the service generators, transformers and switchboards, erection space, main station elevator, maintenance shops and stores, lubricating and insulating oil plants, battery rooms, a fully equipped hospital room, also kitchen and dining room and offices. The intention is to duplicate nearly all of these services in the extreme north end of the ultimate station.

Permanent railway connections are provided by a track built along the river at the bottom of the cliff from the generating station to the Michigan Central Railway at the village of Queenston. A railway track is built across the river side of the station building on an extended portion of the substructure to give access to the southerly area. A 300-ton crane consisting of two separate units each having a capacity of 150 tons is provided in the generator room for handling generators, transformers and other apparatus. Electric hoists are located throughout the station to facilitate the handling of equipment.

Turbines.*

The turbines have a capacity of from 55,000 to 65,000 brake horse-power under 305-ft. head. The draft tube on No. 1 unit is of the common curved type modified at the elbow, whereas each of the other units is equipped with a Moody spreading tube. In the design of these units care was taken to ensure good lubrication for the gate stems and to assure that all wearing surfaces were well greased. The use of labyrinth seals on the runner rims reduces leakage to a minimum. It will be noted on the section that the top portions of the draft tubes are of cast iron, and these are so arranged for units 1 to 5 that they can be lowered to facilitate the removal of the runner from below, thus dispensing with the necessity of the dismantling of the generator. Owing to the presence of a considerable amount of sand in the water during periods of flood, and by reason of dredging operations in the upper canal, a pressure sand filtering plant has been installed to filter all water supplied to the lignum-vitæ bearings, in order to prevent scoring of the turbine shaft. The lignum-vitæ bearings themselves are about 6 ft. long, and in order to ensure lubrication over their entire length the water is admitted both at the middle and at the top of the bearing. A flow meter, with an indicator and an alarm light, is connected to the bearing water supply to guard against any stoppage of the flow continuing long enough to injure the shaft or bearing. The longitudinal passageway on elevation 264 gives access to the turbine bearings, gate stems, servo-motors (Fig. 22), governors, and filters. Air-brakes, which act against the underside of the generator rotor, are provided to bring the unit quickly to rest in case of shut-down. The runners are shown in Fig. 23.

Gratifying results were obtained when the turbine and generator units were tested, two independent tests made on unit No. 5 agreeing with each other within a small fraction of 1 per cent. Two diagrams giving the test results are submitted in Figs. 18 and 19. The outstanding items of interest in connection with these curves are: a maximum overall efficiency of 91 per cent., a maximum turbine efficiency of 93 per cent., an output at the point of maximum discharge of 65,000 h.p. coincident with an efficiency of 85 per cent., and a range in turbine capacity from 30,000 h.p. to 63,500 h.p. with efficiencies above 90 per cent.

* [These turbines were fully illustrated in an article which appeared in Engineering, vol. cxiv, page 31. —Ed. E.]

Johnson Valves.

The lower end of the main penstock terminates in a 14-ft. Johnson valve, the outlet end of which is 10 ft. in diameter and connects to the turbine casing by several sections of cast-steel pipe. Although this type of valve is too well known to require any description, the method of control is worthy of note. Control is accomplished through three 8-in. Johnson valves, which are in turn operated by pistons in cylinders under penstock pressure controlled by a three-way plug valve. When opening the valve in order to fill the scroll case, it is necessary to build up the pressure in the latter so as to balance the pressure on the two sides of the plunger. The operation of the valve is so arranged that this is done automatically by a series of oscillations of the plunger, as soon as the control handle has been thrown into the opening position. In closing, the motion of the plunger is retarded near the end of the stroke to prevent an excess rise in pressure, due to too sudden closing, and also to protect the plunger seat against shock. The control is so arranged that the valve will close automatically in case of a break in the scroll-case. A remote hand control is also provided so that the valve may be closed, if necessary, from the control pedestal on the main operating floor (Fig. 21, Plate XXV). Access to the valve is from the floor on elevation 264, while the valve itself is located in a chamber which provides space for dismantling the valve. The 5 ft. 6 in. service penstock terminates in a steel plate Y, the two legs of which are each equipped with a 36-in. Johnson valve for each service turbine.

Governors.

The governor system for the main units uses filtered water containing a small percentage of bichromate of potash. This is supplied to the governor at from 150 to 200 lb. per square inch pressure from two motor-driven centrifugal pumps which feed into an accumulator tank for each unit. The return fluid from the servo-motors is carried back through a return main to two concrete tanks so arranged that one tank may be emptied and cleaned while the other is in operation. It had been found in other installations, where a central pumping system capable of handling the completed plant was initially operated to supply only one or two units, that difficulty was experienced owing to the large-capacity pumps heating up the small amount of fluid in circulation. To avoid this, a small-capacity pump was also installed to supply governor pressure during the early stages of operation, and was afterwards to be held in reserve for an emergency. To guard against a shutdown due to the failure of the governor pumps, an emergency connection has been provided to pass direct penstock pressure into the governor-system header. This permits the governors to operate on penstock pressure at any time that the pumping system is out of service, and was called into service when the first two units were operating.

Owing to the small ratio of length of penstock to head (about $1\frac{1}{4}:1$) and the large flywheel effect of the generator rotors, the regulation of these units is a comparatively simple problem.

Generators.

The present units are each rated at 45,000 kv.-a., 80 per cent. power factor, 12,000 volts, three-phase, 25 cycles at 187·5 revolutions per minute. They are capable of being operated continuously at 49,500 kv.-a., with either voltage or current 10 per cent. in excess of the rated values. The units are vertical (Figs. 20 and 21) with direct-connected shunt-field commutating-pole, 520-volt, 150-kw. exciters. The over-all efficiency of the generating units is slightly in excess of 97 per cent. at power factor of 80 per cent. The thrust bearing is designed to support a load of 1,000,000 lb., which is slightly in excess of the weight of the rotor plus the hydraulic thrust imposed by the turbine. Upper and and lower guide bearings are provided, the latter on account of the length of shaft and in order to keep the generator a self-contained unit.

The quantity of air required for cooling is 120,000 cub. ft. per minute. It is interesting to note that the weight of air passing through the generator every $2\frac{1}{2}$ hours equals the total weight of the generator, namely, 1,400,000 lb. The units are completely enclosed, the air being drawn either from the outside or the inside of the generator room, or from both, and discharged through ducts into the atmosphere or to the different sections of the building for heating purposes. With five units in operation at rated load, there will be available for heating the building 5,400 kw., which corresponds to 1·2 kw., per 1,000 cub. ft. of building contents. This should be ample for heating the building at all times.

The maximum observable temperature which any portion of the unit will attain under rated conditions as obtained by thermocouples will not be in excess of 105 deg. C. with 40 deg. C. ambient air. The temperature as obtained by thermocouples is indicated on the control pedestal adjacent to the generator, and also in the control room.

Units 1, 2 and 3 are all of the same make, having a rotor with cast steel spider and laminated built-up sheet steel rim, dovetailed to the spider. These three units have upper and lower bearing brackets of cast iron, and are provided with the Kingsbury thrust bearing. Armature windings are insulated in slot portions with sheet mica insulation ironed on, whereas the end portions of the windings are insulated with mica and varnished cambric taping. The stator is divided vertically into four 90 deg. sections.

Units 4 and 5, being made by a different manufacturer have a rotor made up of seven cast steel sections, five of which carry the pole pieces. The other two—one above and one below—are provided for additional flywheel effect. Upper and lower brackets are of cast steel and a spring supported type of thrust bearing is used. The armature coils are insulated throughout with mica tape. The stator is divided into three 120 deg. sections. The flywheel effect of each unit is 21,500,000 W.R.^{2}. The rotors are required to stand an overspeed of 185 per cent. of rated speed. Insulation tests are specified of 30,000 volts on armature and of 2,500 volts on field and exciter. The over-all diameter of these units is 25 ft., the diameter of rotor over pole faces being about 18 ft. The shafts are 30 in. in diameter in the guide bearings and are provided with a flange at the lower end for bolting to a corresponding flange on the turbine shaft. The shafts are hollow with 8 in. diameter bore and are 30 ft. 3 in. long. The

Fig. 18. OVERALL EFFICIENCY & POWER-DISCHARGE RELATION FROM TESTS MADE MAY 20TH 1923. 305 FT. HEAD.

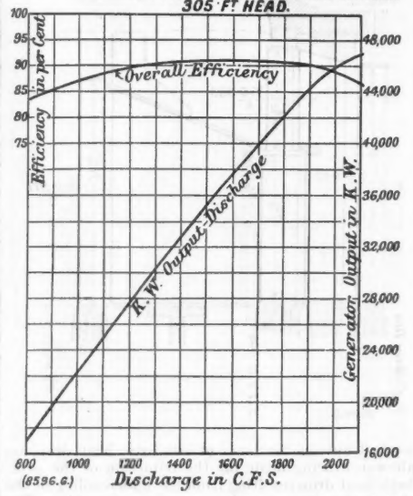
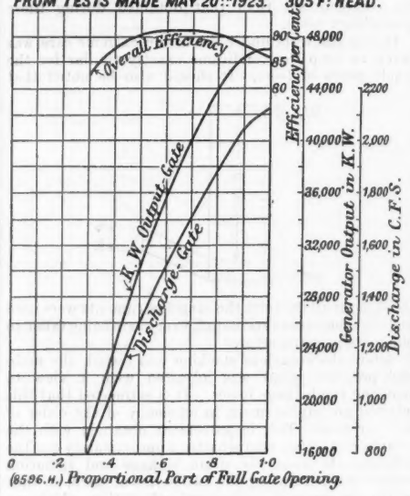


Fig. 19. GATE OPENING-DISCHARGE & POWER-GATE OPENING RELATION FROM TESTS MADE MAY 20TH 1923. 305 FT. HEAD.



over-all height of generators above the generator floor (elevation 284) is 26 ft. 10 in. Thus above the main floor (elevation 297) only the top of the frame and the upper bracket thrust bearing housing and exciter are visible (Fig. 21). The weight of the complete generator is 1,400,000 lb., that of the rotor 615,000 lb. The largest piece to be handled by the cranes weighs 600,000 lb.

CONSTRUCTION OPERATIONS.

As excavating methods have been described so frequently, only the salient features wherein the work differed materially from ordinary construction will be discussed. Through the earth overburden, a trapezoidal section was excavated; this was sloped sufficient for stability after rip-rapping and a berm on each side was left at the bottom of the earth excavation sufficient to provide for loading-tracks. The rock was excavated sufficiently to provide a 48 ft. concrete-lined waterway. An electrically-driven shovel with a 90-ft. boom and 58-ft. dipper stick capable of handling an 8 cub. yard dipper was used. With few exceptions these units could work in earth excavation from the rock surface, loading on tracks on the top of the slope, thus exposing in one operation the whole side for rip-rapping.

The earliest designs of the rock section called for a channelled face from top to bottom. At a later date, however, this feature was revised and only the uppermost 10 ft. of rock excavation was channelled and this was done principally to preserve the integrity of the rock berms for the loading-tracks. Below the 10-ft. level the sides of the excavation were prepared for concrete by deep close drilling.

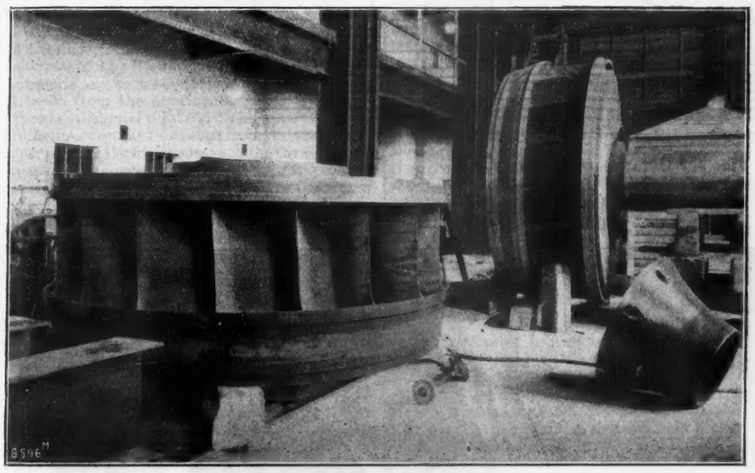


FIG. 23. VIEW OF TURBINE RUNNER.

The rock face in the deeper section was shot in single rounds at intervals of 11 ft., and for this purpose holes to a maximum depth of 55 ft. heavily sprung were loaded. About a pound of 60 per cent. dynamite per cubic yard of solid material was employed. Areas for disposal of the large quantities of excavated materials at distances of from 1 to 3 miles from the line of the canal were arranged and were operated to provide a fill with a 40-ft. face by side dumping. A similar face was provided also by temporary trestling.

The handling of 12,000,000 cu. yds. of dry earth excavation and 5,000,000 cu. yds. of rock, together with 500,000 cu. yds. of concrete ingredients, other structural materials and plant, could hardly be conducted properly without a complete and efficient system of trackage. As part of the earlier construction programme, connections and transfers were arranged with the principal railway lines and storage and sorting yards established at central points. The main-line double-track railway was constructed parallel to the location of the canal from end to end and connected to the several yards. These tracks together with loading and service tracks and double-track lines to the various disposal areas, made up a total of about 90 miles of single-track railway; all of which were of the best heavy construction and provided with overhead trolley wire for electric operation.

The disposal of excavated materials was handled almost entirely by twenty-six 55-ton electric locomotives, and a similar number of steam locomotives were in use for yard and service duties, and also for moving excavated materials as an adjunct to the electrical equipment. The standard spoil train was made up of eight 20-yard all-steel side dump cars, equipped with compressed-air apparatus for discharging.

Canal Lining Plants.—The sequence of operations in lining the canal was:—First, the paving of a strip 15 ft. wide on each side of the floor; second, the construction of the side lining in alternate panels, 40 ft. in length; third, filling in of the intermediate panels of the lining; and fourth, the paving of the centre strip of the floor. The outstanding problems to be solved in connection with the lining of the walls of the canal were the extreme heights to be concreted in a single operation; the disposal of seepage; the necessity of obtaining the best results in regard to density, smoothness of finish and adhesion to the rock; and the great distance over which the operations extended.

By the end of 1920, two miles of the canal prism had been excavated to grade and made ready for concreting. The programme for concreting the remaining distance of 5½ miles had to be adjusted to suit the operations of the five high-lift shovels, which were working in separate openings and scheduled to finish simultaneously. It was necessary, therefore, to install more lining equipment than would have been required, for the sole purpose of completing the concrete work immediately after the shovels had finished the excavation. This programme was carried out so that excavation was completed on November 30; concreting was finished on December 18, and water admitted to the canal on December 24, 1921.

From November 1, 1920, to December 17, 1921, 410,000 cub. yds. of concrete were placed, 379,000 cub. yds. of this being placed in 1921, while 332,000 cub. yds. of this latter quantity were placed from May to December, inclusive, or at an average rate of 41,500 cub. yds. per month. The record day's pour was 3,046 cub. yds., with 17 plants operating; the record week was 18,278 cub. yds. and the record month 63,362 cub. yds.

The average amount of cement used per cubic yard of concrete of all classes on this work has been 1·28 bbl. of 350 lb. net weight. The Canadian standard barrel of cement is equivalent to 1·19 bbl. in American units. The averages for the different classes have been as follows:—

Class.	Minimum Compressive Strength at 28 days. Lb. per Sq. In.	Barrels of Cement. Per Cub. Yard of Concrete	
		Can. BBL.	U.S. BBL.
A	2,500	1·67	1·55
B	2,000	1·46	1·36
C	1,500	1·20	1·12
D	1,000	0·98	0·91

Approximately 235,000 cub. yds. of sand were purchased. Half of this was obtained from a pit accessible from the tracks of the Commission, and the rest from Lake Ontario. Both deposits contained materials of excellent quality.

In addition to the Queenston-Chippawa development, the Commission operates 21 hydro-electrical plants to supply the electrical energy for its several systems. Electrical plants, now operated and under development by the Commission, will, when completed, have an aggregate capacity of 1,000,000 h.p.

The largest of these other plants which the Commission has constructed is what is known as the Nipigon development, installed for supplying power to the Thunder Bay district. This district is situated at the north-west of Lake Superior at the head of the navigation of the Great Lakes, the two principal communities in the district being the city of Port Arthur and the city of Fort William. The Nipigon development provides at present for an installation of 75,000 h.p. with extension to 100,000 h.p. A substantial portion of its output is being employed in connection with the pulp and paper industries of the district.

In conclusion, I should like to say that the small initial load of less than 1,000 h.p. with which the Hydro-Electric Power Commission commenced its operations in 1910 has increased, until to-day the Commission is distributing 750,000 h.p. The transmission lines of the Commission total a length of about 4,000 miles, and include over 580 miles of 110,000-volt lines. The greatest single distance to which power is transmitted is from Niagara Falls to the city of Windsor, a distance of approximately 250 miles. The Commission has invested in its hydro-electrical undertakings about 195,000,000 dols., and the municipalities have invested in their own distribution systems and in other assets relating to their electrical enterprises about 65,000,000 dols., making a total investment in the undertakings with which the Commission is associated, of over 250,000,000 dols. Over 360 municipalities are supplied through the agency of the Commission. The extent of these operations justifies the provision of this large Queenston-Chippawa development.

When it is remembered that the progress briefly outlined to you respecting the Commission's work has been accomplished in less than 15 years, it will be recognised that the operations of the Hydro-Electric Power Commission of Ontario constitute an outstanding example of the rapid development of electrical markets and a vindication of the policy of making available to the greatest number of people of the province of Ontario the inestimable advantages of low cost electrical service.

AN ECONOMICAL DESIGN FOR ARCH CENTRES.*

By A. E. WYNN, B.Sc. (Birmingham), Assoc.M.Am.Soc.C.E.

THERE is not very much literature on the design of centring for reinforced concrete arches. An examination of handbooks and text books on reinforced concrete reveals a few pictures but mostly of bridges with some particular feature requiring a special treatment of the centring. Magazine articles on reinforced concrete bridges usually neglect to describe the construction of the centring, passing it over with such remarks as "the centring presented no special difficulty" or "the centring was of the usual bent type." Now to the bridge contractor this is the most important part of his work, and on it may be said to depend the successful completion of the bridge. He is always pleased when the arch ring is poured and stripped as he knows then that most of his troubles are over. Centring is designed more by practice than theory, and for that reason more descriptions of designs used successfully would be welcomed by the bridge engineer and contractor. The contractor is naturally interested in economy, and wants to know how light he can make his design and at the same time ensure sufficient strength.

Each bridge will present a different problem from the last, but it is possible to practically standardise the design of the centring so that the lumber can be used over and over again, and this means economy. Unless there are special conditions, requiring the use of steel or timber trusses, the design will usually be of the bent type. No two engineers will design a bent centring in the same way, as there are an infinite number of arrangements of spans and sizes of timbers to choose from. The problem is to find the most economical one for the case in question, under certain conditions pertaining, also bearing in mind that the lumber will probably be needed for another job. The centring described in this paper was built in the fall of 1922 for a bridge over the Salmon River at Pulaski in New York State (Figs. 1 to 4, Plate XXVI, and page 258). The design, being so successful in its first use, has been adopted practically as a standard by the contractors and this design, and the same lumber is being used for the third time. The economy in being able to use the lumber several times over is obvious. This cannot be done if such sized timbers are used that cannot be easily adapted to different conditions. The Pulaski Bridge is a two-rib open spandrel arch of 200 ft. clear span and rise of 26 ft. 6 in., the distance from the crown to the river bed being about 40 ft. The ribs are 3 ft. deep at the crown and 5 ft. 6 in. at the springing and vary in width parabolically from 5 ft. 4 in. to 7 ft. As construction was not started until the middle of September, speed was of the utmost importance, as it was desired to complete the arch ribs and have them stripped before cold weather

* Paper read before Section G of the British Association at Toronto on August 13, 1924.

REINFORCED CONCRETE BRIDGE OVER THE SALMON RIVER, PULASKI, N.Y.

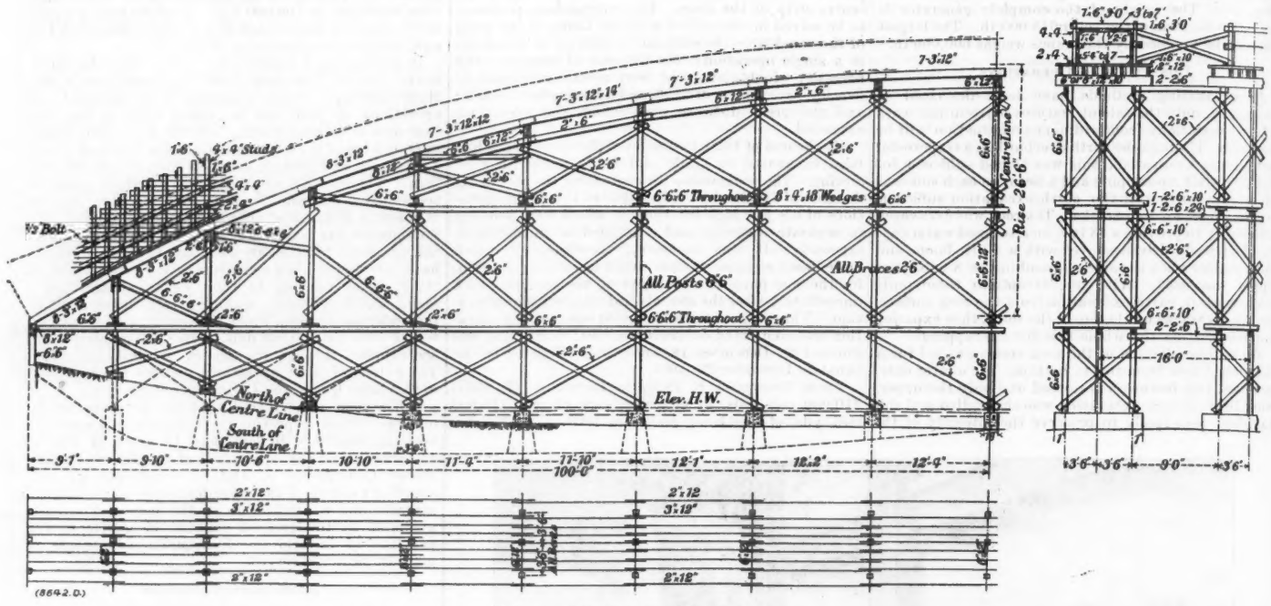


Fig. 3. Details of Centring.

and high water. Before designing the centring, enquiries were made at all the nearby lumber dealers as to their stock and sizes of timbers, since it was impossible to wait for mill shipments. In long leaf yellow pine the only sizes that could be obtained in sufficient quantities were 6 in. by 6 in., 6 in. or 8 in. by 12 in. and 3 in. by 12 in., so that this fixed the sizes of the posts, caps and joists respectively. For lagging $1\frac{1}{4}$-in. spruce was not available, so $\frac{7}{8}$-in. by 6-in. tongued and grooved pine was used. Two-inch by 6-in. rough spruce was used for bracing. All the sizes were somewhat lighter than are usually used for an arch centring of this size and an arch ring of this weight. The design, therefore, had to be made to fit the lumber available, obtaining the maximum use out of each piece. As centring is only a temporary structure and the load to be carried is definitely known, higher stresses can be used than is customary in permanent work. On the long-leaf yellow pine joists and caps an extreme fibre stress of 2,000 lb. sq. in. in bending was allowed and 200 lb. sq. in. for horizontal shear. A unit stress up to 800 lb. sq. in. was allowed for compression across the grain.

The design was made, as far as possible without using different sizes, so that each member was fully stressed. Assuming an average load on the joists from the arch ring, it was found that at 12-in. centres a 3-in. by 12-in, would span a little less than 12 ft. As they could only be obtained in 12-ft. and 14-ft. lengths, this was satisfactory, and a uniform spacing of 12 in. was kept throughout. It is better to keep the joist spacing constant and change the spans than to keep the spans constant and change the spacing. This required nine bays to half the arch, but since it was desired to fully stress the joists the bays could not be equal since the load increased from the crown to the springing. From looking at the thickness of the arch ring it could be seen that near the crown the thickness did not increase appreciably so that the bays could be of equal or nearly equal spans, but that near the springing the increase was rapid, so that the bays would have to be made shorter and shorter, decreasing by a greater amount each time. A spacing was therefore assumed which was expected to give equal stresses in the joists throughout. At each bent the weight of the arch ring was calculated and resolved normal and tangential to the intrados. The tangential component was neglected and the radial component was used in calculating the joists.

Since it did not vary much from one end to the other in the short length of joist, the average was taken and assumed as uniform all over. To this loading was added 60 lb. per sq. ft. for construction live loads. This added live load was small because the concrete was wheeled over the old bridge and not over the centering and was deposited through chutes and not dropped. Using the maximum allowable stress the assumed spans of the joists was checked and slightly changed where necessary. With a bearing stress of 400 lb. per sq. in 4 in. bearing was required, while the

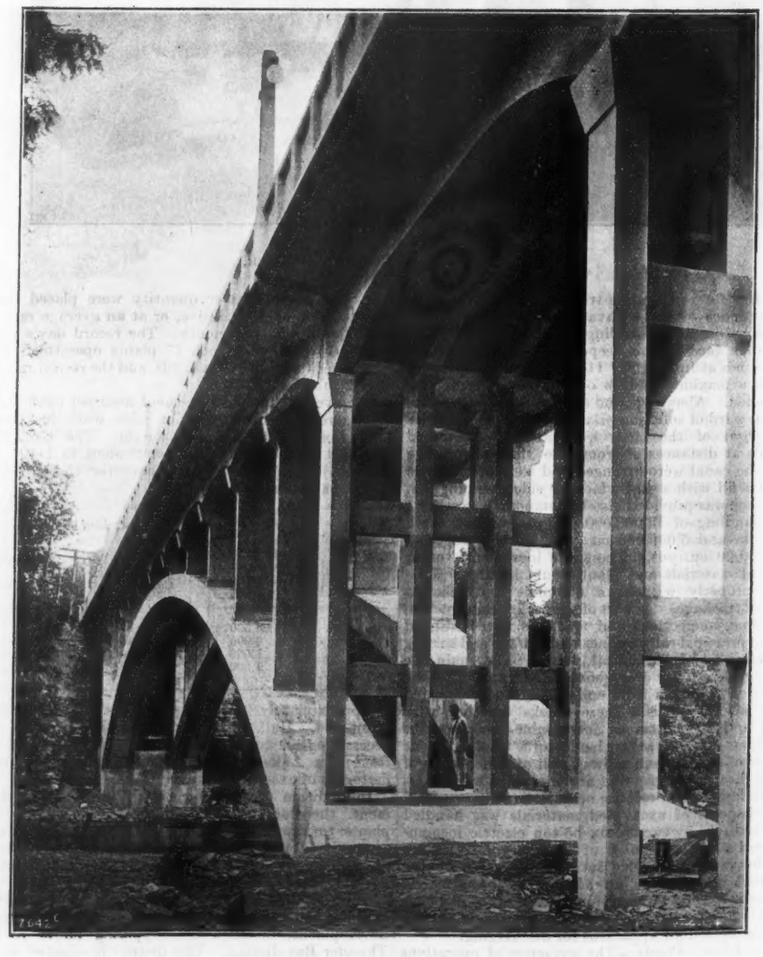


Fig. 4. View of Underside of Completed Bridge.

greatest deflection would be less than ¼ inch. As the arch ribs widened out, one more joist was used for the four bays nearest the abutments. To carry the overhanging lagging to form a walk alongside the ribs, 2 in. by 12 in. spruce was used. As 7 ft. was the maximum width of ribs the same width was used for the bents, using three posts 3 ft. 6 in. apart for each rib.

From the loads carried by the joists the caps were calculated, and it was found that the allowable unit shear governed the size as is usually the case with heavy loads on short spans. An 8 in. by 12 in. was used until a 6 in. by 12 in. was strong enough, and this size was kept throughout, although near the crown a smaller timber would have been sufficiently strong. The loads on the posts varied from 26,000 lb. to 20,000 lb. on the centre posts, and from 14,000 lb. to 11,000 lb. on the outside posts. Using 6 in. by 6 in. posts the compression across the grain of the caps varied from 800 lb. sq. in. to 600 lb. sq. in. Although this was high it was considered safe, as some biting into the grain was expected and allowed for. Results showed that this biting was inappreciable. The allowable unit compressive stress on the posts was 1,200 lb. sq. in. reduced according to Winslow's formula of allowable stress per sq. in. The greatest length of post was 12 ft. and it required three tiers to reach the arch ring. Each tier of posts rested on cross caps of 6 in. by 6 in. timbers and these in turn rested on longitudinal caps of 6 in. by 6 in.

The cross caps greatly stiffened the structure and the longitudinal timbers stiffened the structure, and formed a good working platform, and especially were used to take the thrusts from the arch ring on the top caps. The lower row of 6 by 6's were wedged each end against the abutments and took the thrusts on the caps of the second bents from the abutments, being transferred down through diagonal 6 by 6's. The upper row took the thrusts direct on the third caps from the abutments. The upper posts in the fifth bents took the thrusts on the fourth caps. The joists were notched over and wedged tight against the caps to prevent the caps from overturning and to get a bearing of at least 4 in. Wedges were placed at the bottom of the upper posts and between the cross and longitudinal 6 by 6's. They were cut from 4 in. by 8 in. by 18 in. beechwood. All bracing was 2 in. by 6 in. rough spruce, which is lighter than is ordinarily used for this purpose.

A row of braces connected the posts just below the caps, and each bay was diagonally braced both longitudinally and across the bents, and the bents for each rib were connected by horizontal and diagonal braces.

To support the posts several methods were considered. The water varied in depth at high water from 6 ft. to a few inches and had a rise and fall of 2 ft. due to the opening and closing of a dam upstream. The river bed consisted of about 8 ft. of gravel overlying rock, the gravel being rather loose on top, the small material having been washed out. Piles could not be driven in this material. With timber mudsills there would have been too much danger of settlement as the loads per posts were high, 10 to 13 tons. To determine how much the soil would safely carry a 2 ft. square concrete pedestal was cast on the river bottom and loaded up with old steel. It was found that 1½ tons per sq. ft. could safely be put on the foundation without any appreciable settlement. It was, therefore, decided to support all the posts on concrete pedestals proportioned for this loading. They were all made 9 ft. long to take three posts of a bent and varied from 3 ft. to 18 in. at the bottom to 18 in. at the top, the greater width in the deep water to prevent overturning. The forms were made on shore, set in the water, weighted down and filled with 1:3:6 concrete mixed from gravel dug out of the river bed. The tops of the pedestals were a little above low water and the posts were set directly on them.

The contractor was greatly helped in the construction of the centering by the fact that the old steel arch bridge was left in place until the arch ribs were poured and so could be used as a working platform. A hand which fastened to an A frame was the only plant used in erecting the centering. It is interesting here to note that the arched lower chords of the old bridge were concreted in the new ribs and the diagonal members and the horizontal top chords were not cut off until the new bridge was completed. Each member of the centering was erected separately, as this method was considered to be cheaper and quicker than trying to handle built-up units. Only sufficient braces were placed at first to hold the posts in position, the object being to build up to the full height as quickly as possible, and then while the lagging and reinforcing steel was being placed, to complete the bracing.

The top row of braces was only lightly spiked on until the posts were wedged up to their final position, this being given by instrument readings on the lagging at each bent. A crown of 2½ in. was given the arch to allow for possible settlement. The actual settlement obtained was 1¼ in., of this ¼ in. was due to take up in the timbers while pouring, ½ in. after removal of forms and ½ in. due to rib shortening. To obtain the curvature of the joists, the full half arch was laid out on a platform of 1 by 6's. The joists were adzed to the curvature required. As the arch was flat this did not mean much cutting away of the joists and was cheaper than adding curved strips as is often done. The joists were lightly toe-nailed to the caps to hold them in position, no cross bridging was used.

Contrary to usual practice no bolts were used in any part of the structure. Instead spikes were used throughout, each brace being connected to the posts with four spikes each end.

Using spikes instead of bolts was not only quicker and more economical but gave a stiffer structure. The labour cost of drilling holes, fitting and tightening bolts and nuts is high, while there is little salvage of the bolts, as they are easily lost and their first cost is high. Also bolt holes tend to become elongated, and it is difficult to tell whether the nuts are tight without testing each one. The caps were fastened to the posts with 1 in. by 6 in. scabs securely spiked to prevent the joists turning them over. The whole centering was completed in 15 working days at a cost of 25 dols. per thousand board feet of lumber, exclusive of foundations which cost 5 dols. per thousand.

The total amount of lumber used, exclusive of the lagging was 48 thousand board feet. The method of stripping the centering was interesting and probably unique. As it was now December with very cold and snowy weather, and a partly frozen river speed was very important, and the superintendent was allowed four days to dismantle the centering and pile the lumber up on the bank with a gang of only 2 carpenters and 5 labourers.

The wedges were loosened in pairs, starting from the crown. The top row of longitudinal braces and those connecting the bents were then knocked off. Ropes were passed around the arch ribs, underneath the joists and lagging, one rope at each bent, thus tying the joists and lagging up to the ribs. The top centre bent was then removed, and a rope fastened to the cap of one of the bents, and three or four bents were pulled over by man power on to the bents below, where they knocked apart and the timbers dropped on to the ice. The same method was used for the lower bents. As fast as the timbers were dropped on to the ice they were carried ashore. When all the bents were down the ropes around the ribs were slackened and the joists and lagging dropped to the ice two bays at a time. As few spikes were used to connect the lagging to the joists, the lumber became separated in dropping.

It may be thought that there would be considerable damage done to the lumber by this method, but this was not so.

The timbers were too heavy and the lagging too light to be damaged by falling, and the only broken pieces were a few braces, that were wrenched off when the bents were pulled over.

The dismantling of the centering was done within the time allowed at the low cost of three dollars per thousand board feet. The heavier concrete pedestals were washed out in the spring floods, so no destruction of them was necessary.

Each rib was poured simultaneously in six sections of equal volume, symmetrically placed with regard to the crown, with keyways left at the crown and abutments.

The centering was loaded symmetrically, and a carpenter was on watch all the time during concreting to tighten wedges if necessary and to watch for any signs of weakness.

From level readings at the crown before and after pouring the settlement due to concreting was ¼ in., which was very much less than expected, and was all due to take up at the joints, giving about $\frac{1}{32}$ in. at each cross grain bearing. This amply justified the use of a high bearing stress on the timbers.

Much interesting information was obtained from the success of this centering, since departure from usual practice was in the use of very light short timbers, light bracing, high unit stresses and the use of spikes instead of bolts, all of which were proved to be satisfactory.

It is doubtful whether the horizontal and diagonal 6 by 6's were required to take the thrusts on the caps since there was no sign of the joints closing up under compression. If these members took any thrust at all, it was not transmitted throughout their whole length, however, they were useful in giving a good working platform and additional stiffness.

When the joists are notched over and wedged to the caps and the caps well scabbed to the posts, there should be no danger of the caps overturning from the horizontal thrusts.

There was probably too much longitudinal bracing. The top tier of posts should be well braced as they have to take most of the shock and thrust, but no doubt half as much bracing in the two lower bents would have been sufficient.

The same general design and lumber was used on a second bridge of three barrel arches of 63 ft. span each. Only one tier of posts was necessary, and as the loads were lighter the joists were placed 27 in. apart, and the caps were 6 by 6 spaced 4 ft. 6 in. on centre across the arch and about the same spacing longitudinally as before. The joists were adzed to the new curvature.

The lumber is now being used on the third bridge of three barrel arches of 70 ft. span each. Two tiers of posts are being used, and other details are the same as were used at Pulaski, adapted to a barrel arch with lighter loads to carry.

If heavier timbers had been bought in the first place they could not have been used to advantage in the smaller bridges without waste of material, whereas small size timbers can be used to the limit of their strength under almost any conditions.

ILLUMINATING ENGINEERING SOCIETY.

ON Tuesday, August 12, a conference of the Illuminating Engineering Society was held at the British Empire Exhibition, when papers were read dealing with various lighting problems. A contribution of Mr. G. L. Jennings, of the Brentford Gas Company, was entitled "Some Notes on the Gas Lighting at the British Empire Exhibition." In it Mr. Jennings recalled that practically the whole of the amusement area of the White City was lighted by high pressure gas. The author believed, however, that there was now no need to employ this system for really effective gas lighting. At the Exhibition two low-pressure lamps, 14½ ft. from the ground to reflector, were used on each standard. The lamps had been placed 60 ft. apart, 30 ft. separating the columns across the road. The lamps were of a new pattern, consisting of a strong copper exterior and cast superheater. There were 16 mantles in each lamp. The weight of the lamp was 42½ lb., so that everything connected with the fixing of these lamps had to be solid. So far, including the by-pass and lamp, the consumption worked out at under 34 cub. ft. per hour per lamp, *i.e.*, slightly over 2 cub. ft. per mantle. There were situated at various places in the grounds where it was desirable that extra light should be given or where the light could be seen from a distance, a number of columns carrying four lamps, making a total of 64 mantles with an observed candle-power of over 6,300. The columns of these were made taller, the actual casting being 14 ft. 6 in. and the lamps had been fixed at a height of 17 ft. to the reflectors.

In his paper "Some Notes on the Electric Lighting at the British Empire Exhibition," Mr. Hadyn T. Harrison stated that the original scheme was to deal with the outside illumination of all buildings, excluding the amusement park, as one complete scheme on novel lines, but this had been found impracticable. This original scheme was to illuminate all the facias of buildings from the roofs of adjacent buildings, with the object of avoiding the distortion of architectural features such as occurs with illumination from ground level or sources at low altitude. The absence of such flood lighting in certain sections had made it necessary to add supplementary festoon lighting not originally intended. The surfaces of the most beautiful buildings were of concrete with reflecting values as low as 25 per cent. and from 2 to 5 foot candles were found necessary to produce a good effect with white light. In the case of plastered or painted buildings less than half this value was sufficient. Owing to the long distance between buildings highly concentrating projectors were necessary. The problem was solved by the use of low voltage gas filled tungsten lamps with concentrated filaments, and deep short focus parabolic reflectors, which directed 76 per cent. of the total luminous flux within an angle of less than 5 deg. —probably the highest degree of concentration yet obtained with an incandescent filament as the light source. With a 100 watt 12-volt lamp these projectors produced 300,000 candle-power at the centre of the beam, 200,000 candle-power at 1 deg., and 100,000 candle-power at 2 deg. on either side, the overflow being exceedingly small. The main feature of the lighting of the grounds was the use of sources of low intrinsic brilliancy and high power, with a view to eliminating all unpleasantness due to glare. The beautiful spherical globes designed by the architects were erected at a low altitude for artistic reasons, but as the luminous area exceeded 900 sq. in. the brilliancy was low despite the fact that these lanterns furnished 600 to 1,000 candle-power. Flashed opal glass was used to obtain uniform brightness. The interior lighting included the illumination of some of the largest buildings in the world. The light sources were gas-filled lamps suspended as high as possible. Lamps were in general equipped with concentrating reflectors of the vitrous enamelled steel type, the resultant floor illumination of 3-foot candles being obtained with an expenditure of less than 0·3 watts per square foot of floor surface.

In a paper entitled "The Best Means of Promoting Public Appreciation of the Benefits of Good Lighting," Mr. L. Gaster, gave some notes on the proceedings at the first International Conference on Industrial

Hygiene and the meeting of the International Illumination Commission held in Geneva, in July, 1924. The conference had cordially approved the view that good lighting, in common with proper ventilation, heating and sanitation was essential to the health of the workers.

One of the most pressing needs was considered in "The Illumination of Highways from the Motorist's Point of View," a contribution of Mr. Edward H. Fryer, Head of the Road Department of the Automobile Association. He stated that motorists' requirements fell into three groups :—

(1) Illumination provided on their own car or motor-cycle ;
(2) Extraneous lighting ; and
(3) Warning lights.

Climatic difficulties ruled in each group, while the provision of more light could possibly endanger other road users. In the opinion of Mr. Fryer the most satisfactory form of lighting (electric) for a motor-car could be summarised as follows : Two headlights mounted so that the nearest one focused straight ahead and the off-side one focused slightly towards the near side. An auxiliary light under the near-side dumb-iron was advocated, fixed a slow as possible and focused on to the edge of the road (when driving a yard or so from the edge) at a distance of 8 to 10 yards ahead of the car. These three lights should be controlled by a couple of switches handy to the right thumb. Two side lights, the near-side one focused with a horizontal beam and the off-side one depressed so as to avoid dazzling vehicles travelling in the opposite direction, and one tail light on the off side completed the equipment.

With regard to street lighting a national standard was most desirable, for the reason that traffic on the roads at night was bound to increase. Reasonable requirements in regard to street lighting were even illumination of the roadway ; no flare or dazzle from naked lights ; and no shadows. A uniform height of suspension of the lights, together with uniform distance between the lights was essential. Illumination of danger points was necessary. Possibly the ideal system of street lighting would be from lamps fitted with parabolic reflectors, projecting a strong beam in the direction of proceeding traffic, but fixed at such a height and angle as to avoid dazzling drivers on the other side of the highway proceeding in the opposite direction.

Motorists had subconsciously developed the habit of overtaking red lights by going to the off side and keeping to the near side when white lights appear, and it was suggested that this simple principle should be adopted in lighting all highway obstructions.

THE RENOLD HOLLOW-STUD STEEL DRIVING CHAIN.

The steady increase in the use of chain drives for many classes of machinery, together with the tendency of many makers to construct machines for more arduous work, renders the provision of satisfactory driving chains of the utmost importance. The malleable cast-iron type of chain has done, and continues to do, excellent work for elevating and similar machinery, but in view of general developments Messrs. Hans Renold, Limited, of Didsbury, Manchester, have introduced a form of steel chain suitable for various rough and heavy machines, driving, elevating and conveying machinery, &c. The elimination of cast iron for tension members, which this all-steel chain necessarily involves, will appeal to many users, while, as will be obvious, the chain has qualities of lightness combined with strength, accuracy of pitch and bearing surfaces which are of great value. The qualities of any chain are naturally a reflex of the methods of the people who make it, and in this case, in view of the record of Messrs. Hans Renold, it is not necessary to say that the product is of the very highest class. The new hollow-stud chain of the firm is illustrated in the annexed figures. The various sizes are in general built to run on the sprockets which are commonly used for malleable chains, and to the standards of such chains it also conforms in pitch, diameter of bush and inside width.

The side plates of the chain are made of rolled steel and, consequently, give the necessary tensile strength for a minimum of weight. The bushes and studs are made from rolled steel strips formed to shape, or in certain sizes are machined from steel tubes. They are fixed rigidly into the side plates by force fits that are correctly proportioned to the size of the parts. In the hollow-stud chain the bushes and studs are cylindrical and forced into round holes in the side plates. These side-plate holes are a few thousandths of an inch smaller than the bushes or studs, and the force fit so obtained will resist any effort to turn them which the work of the chain can produce. As an additional precaution the ends of the hollow rivets are slightly expanded. This sytem is superior in that cylindrical parts and round holes can be made to the necessary degree of accuracy by methods that are a manufacturing proposition. The wearing surfaces are smooth and case-hardened, and all scale is polished off after hardening. The turning of the chain joints when the chain is in action takes place between glass-hard polished surfaces, which are very large in proportion to the load capacity of the chain.

In some cases a roller is mounted on the bush to bring the diameter up to that of the gearing barrel of the particular malleable chain that is to be replaced.

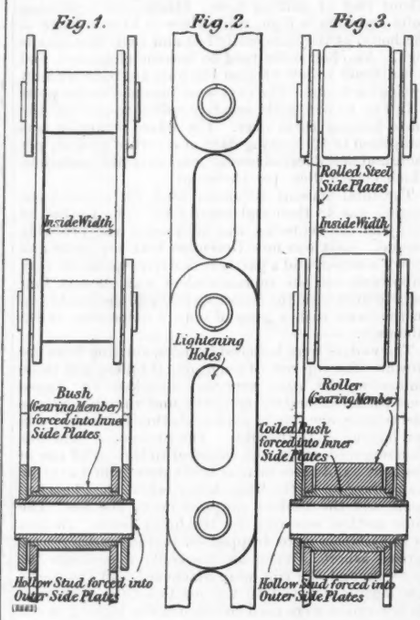


Fig. 1.
Fig. 2.
Fig. 3.
Inside Width
Bush (Gearing Member) forced into Inner Side Plates
Hollow Stud forced into Outer Side Plates
Lightening Holes
Rolled Steel Side Plates
Inside Width
Roller (Gearing Member)
Coiled Bush forced into Inner Side Plates
Hollow Stud forced into Outer Side Plates

In others the bush itself gears with the sprocket teeth, while occasionally the rollers are made large enough to stand above the side plates to enable the chain to roll along a guide track. Various other modifications are given in detail in "Chains for Conveying and Elevating Machinery," an interesting publication of Messrs. Hans Renold, Limited, which should be in the hands of all users of heavy chain drives. In this book the new departure in chain making is described, namely, the provision of steel links in place of malleable iron ones in conjunction with the design embodying hollow studs throughout. With these chains attachments of all kinds can be simply secured to the chain at any desired spacing. This permits standardisation of chain parts and gives the added advantages of accurate chain pitch, guaranteed strength, and long life due to hardening.

THE HENDON-EDGWARE EXTENSION RAILWAY.

The opening for traffic on Monday last of the Hendon to Edgware section of the Hampstead line of the London Electric Railway system, marks the completion of the Hampstead and Edgware Railway which was promoted nearly 30 years ago in connection with the original Charing Cross, Euston and Hampstead Tube Railway. The latter was opened for traffic as far as Golders Green in 1906, that station remaining the terminus until November of last year, when the extension line was opened as far as Hendon (Central) station, with an intermediate station at Brent.

Work on the further extension from Hendon to Edgware, which has just been opened, was commenced in November, 1922, so that its construction has occupied less than two years. From Hendon, the line runs in a north-westerly direction for a total distance of 3 miles, passing through twin tunnels under high ground, known as the Burroughs ridge, and under the main line of the London, Midland and Scottish Railway. It then continues on the surface in shallow cuttings and on low embankments to the terminus at Edgware. There are two intermediate stations named Colindale and Burnt Oak, respectively, the first-mentioned being located near the main entrance to the Hendon aerodrome.

The construction of the line presented no particular difficulties, although as many as 10 under or over bridges were required between the Burroughs tunnels and the Edgware terminus. Seven of these bridges are of the steel-girder type, while the remainder are of brick-arch construction. The Burroughs tunnels are of the standard tube type, constructed of cast-iron segments and having an internal diameter of 11 ft. 8½ in. They are 5 furlongs in length, and have a total fall of 50 ft. Rotary excavators were used for the greater part of the tunnelling operations, which occupied a period of nine months' continuous work. Near Colindale station a deep cutting, involving the use of concrete retaining walls, was necessary, and another constructional feature which may be mentioned is a long embankment with a brick-arch opening in the centre to carry a thoroughfare, known as Deansbrook lane, over the line near the Edgware terminus.

The permanent way is of the usual construction, 85-lb. bull-headed rails being fixed in the chairs by steel spring keys. The sleepers are of creosoted fir in the open sections of the line, and of jarrah in the tunnels. The contact rails are of special high-conductivity steel supported on insulators of "Siluminite." At Colindale station a reversing track has been laid, and at the Edgware terminus a scissors crossover has been put down. The track circuit system of electric signalling has been adopted, the signals used being of the daylight-colour type in which the same indication is given by day as by night. Signal cabins are provided at Colindale for working the reversing siding, and at Edgware for operating the scissors crossover on the main roads and the various points leading into a car shed which adjoins the station there ; otherwise all signals are controlled automatically. Telephones are provided at all home signals to enable motormen to communicate with the signal cabin if necessary, and, in the Burroughs tunnels, telephone lines have been installed to which portable instruments carried by all motormen can be connected for use in emergency.

Electrical energy for train operation is supplied from the Lots-road power station, at Chelsea, through the automatic sub-station at Burnt Oak, which we illustrated and described in our last issue on page 227. This sub-station is now in operation, but, owing to the incidence of the building strike, it has not been possible to complete the platform and station buildings at Burnt Oak, and some few weeks must elapse before this station is available for public use. For the same reason the roofing and some other details of the Colindale and Edgware stations are not quite finished, although these stations are open for traffic. The platforms of all stations are of the island type, 350 ft. in length in all cases. At Edgware both the platform and running roads are completely roofed over, so that cars can be stored in the station overnight if necessary, although the car shed adjoining the station provides accommodation for 28 cars. Only the central portions of the platforms are roofed over at the other stations, but, in every case, connection with the booking hall is by means of a covered way from which diverging stairways lead down to the platform. Passimeter booking booths, equipped with automatic ticket-delivering machines, have been installed at all the new stations.

During the busy hours of the morning and evening, through trains run at eight-minute intervals between Edgware and Moorgate, the journey occupying 35 minutes, while, at other times, through trains run at 10-minute intervals between Edgware and Charing Cross, and at five-minute intervals between Colindale and Charing Cross. With the opening of the Moorgate-Clapham section of the City and South London Railway, which is being widened and is expected to be ready for traffic in November next, direct communication between Edgware and South London will be provided, the journey of 15¼ miles occupying about 50 minutes. The work of extending the City and South London line for a further distance of 5¼ miles to Morden is well in hand and should be completed by the end of next year.

British Iron and Steel Production.—The National Federation of Iron and Steel Manufacturers state that the production of pig-iron in July amounted to 611,800 tons, compared with 607,800 tons in June and 655,100 tons in July, 1923. The number of furnaces in blast at the end of the month was 174, a decrease of 11 since the beginning of the month and the lowest number in blast since December, 1922. The output of steel ingots and castings amounted to 693,300 tons, compared with 651,500 tons in June (when the output was affected by the Whitsun holidays) and 639,500 tons in July, 1923.

Contract.—We learn that orders have been placed with the Westinghouse Brake and Saxby Signal Company, Limited, of 82, York-road, London, for the supply of complete automatic electro-pneumatic decking plant at the Great Western Colliery Company's new pit, Tymawr Field. This includes complete interlocking and simultaneous decking for two deck cages, power-operated gates and control of auxiliary cages. Further orders for electro-pneumatic decking plant at the United Steel Company's Orgreave Colliery, Staple Pit Top, have been received, including track rams, skotch blocks, &c., for decking their two-deck cages at one banking level.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The long looked-for revival in the steel and engineering trades is still far ahead, and those who predicted an "autumn boom" have proved to be false prophets so far as trade in South Yorkshire is concerned. All efforts to stimulate a buying movement, up to the present, have yielded little results, and with the termination of the Allied Conference, a renewal of unfair German competition is prophesied. The storm of labour troubles that has overhung the steel trade of this district for the past month has burst, and some 7,000 operatives on Saturday withdrew their labour from three of the largest steel producing firms in South Yorkshire. The firms concerned are Messrs. Samuel Fox and Company, Stockbridge, Messrs. Steel, Peech and Tozer, Rotherham, and the Park Gate Iron and Steel Company. The cause of the dispute is the refusal of the employers to grant district rates and conditions, said to be observed by other firms locally, to unskilled men. On Monday all three firms shut down, the stoppage thus affecting not only the men on strike, but some thousands of others dependent on their work. The output of steel from this district continues well below the average, and the figures for July will reveal a still further drop as compared with the figures for June. The demand for billets and other similar material is only moderate, and furnace masters have been obliged to suspend operations at one or two furnaces, but an improvement is looked for in the near future. The Colonies are still calling for agricultural implements, quarry tools and road-making appliances, but not on such an extensive scale as of late. Encouraging reports are received from manufacturers in the lighter trades. There is a particularly heavy call for picks, hammers, mining requisites and garden implements for export to our Overseas Dominions. Inquiries are broadcast locally from Russia for the supply of files, saws, and general engineering tools, and should favourable rates be arranged a fair amount of business is likely to accrue from this quarter.

New Master Cutler.—At a meeting of the Cutlers Company on Tuesday, Mr. W. W. Wood, of the Wardsend Steel Company, Sheffield, was elected Master Cutler for the ensuing year, in succession to Mr. James Neill.

Strikers and the Dole.—An interesting point connected with the payment of unemployed benefit has arisen out of the strike, referred to above, at Messrs. Steel, Peech and Tozer's, the Park Gate Iron Works, and Samuel Fox and Company. As stated, some 7,000 men are out, chiefly in the Rotherham district. The strikers are all presenting themselves at the Labour Exchange claiming unemployment pay. Their contention is that the firms are refusing to comply with trade union conditions in the district, and that the new Act provides that unemployment benefit shall not be withheld from workers who decline to work in such circumstances. Tests claims will be presented and adjudicated by the authorities.

South Yorkshire Coal Trade.—An all round improvement in the demand for most classes of fuel has been experienced both on home and export account. Best steam hards show a healthy appearance, and are going away for shipment in fair tonnages, while home requirements are substantial. Cobbles and nuts are strong, probably owing to the increased demand for bunkering purposes. Slacks are firm, especially in the better grades. a weakness is observed in inferior sorts. An expansion is noticable in the call for house-coal, and hopes are entertained of this being maintained. An upward tendency is to be found in the request for foundry and furnace coke, while gas coke remains firm. Quotations:—Best branch hand-picked, 32*s.* to 35*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.*; Derbyshire hards, 21*s.* to 23*s.*; Rough slacks 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; Smalls, 7*s.* to 9*s.*

PERSONAL.—We are informed that the firm of Gragiani and Co., Limited, of 110, Fenchurch-street, London, E.C.3, have been appointed General Agents in this country for Messrs. Ansaldo, engineers and shipbuilders, of Genoa, Italy.

SWISS LOCOMOTIVE CONSTRUCTION.—A particularly interesting booklet illustrating and describing the work in locomotive construction of the Swiss Locomotive and Machine Works, Winterthur, Switzerland, over the period 1871–1921, has reached us from the British representatives of the firm, Messrs. Bernard Holland and Co., 17, Victoria-street, S.W.1. Altogether 2,740 locomotives were built at the Winterthur works during the 50 years covered by the booklet, the majority of these engines being of the adhesion type for standard-gauge and narrow-gauge lines. In addition to ordinary steam and electric locomotives, the firm's output has included a number of "fireless" engines and others operated by compressed air, but they have also been responsible for the design and construction of some 400 rack, or mixed rack and adhesion, locomotives for use on mountain railways. The booklet deals particularly with the last-mentioned class of engine, illustrating and describing the development of the various types in an interesting and informative manner. A particularly useful feature is the inclusion of a number of tables giving data of a large number of locomotives for mountain railways in various parts of the world, and including, in each case, an outline diagram showing the general arrangement of the engine. These tables will be found handy for reference by all interested in mountain railways.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There was no weekly market owing to the annual local race holidays, and consequently little is now ascertainable. Cleveland pig-iron output is in excess of needs, and stocks at makers' works are rather heavy, but the position is less unsatisfactory than appears on the surface as most of the iron stored is reported as disposed of, and producers claim that little movement in the direction of increased demand is needed to give rise to a favourable alteration in the statistical situation. The present outlook, however, is not very encouraging, customers being disinclined to negotiate on forward account, believing that prices have not yet touched bottom. On the other hand, there are makers who express the opinion that the worst of the depression has been experienced and that autumn buying will be better than has been promised. No. 1 is quoted 89*s.* 6*d.* to 90*s.*; No. 3 g.m.b., 84*s.* 6*d.*; No. 4 foundry, 83*s.* 6*d.*; and No. 4 forge, 82*s.* 6*d.*

Hematite.—The state of the hematite branch is a good deal less favourable than is that of Cleveland pig-iron. Producers have large unsold stocks of hematite which are being steadily added to, and, with little hope of early material improvement in demand, values continue on the downward curve. Though some firms are asking rather more, no difficulty is experienced in placing orders for Nos. 1, 2, and 3 East Coast brands at 93*s.*, and for No. 1 at 93*s.* 6*d.*, and indeed these figures can be shaded.

Foreign Ore.—Business in foreign ore is little heard of. Though an odd cargo has been sold at less, sellers still base market quotations on best rubio at 22*s.* 6*d.* c.i.f. Tees.

Blast-furnace Coke.—Durham blast-furnace coke is quiet and inclined to weaken. Good average qualities are round about 26*s.* delivered to users in this district.

Manufactured Iron and Steel.—Nothing new of moment is ascertainable concerning finished iron and steel. Works are closed this week for the local holidays. Export prices vary, and the following quotations for home trade are full figures: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; and fish plates, 13*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The steel trade of Scotland continues quiet and movement is very limited. The outlook is not very reassuring as there is little sign of any improvement in buying, and it would almost seem as if everyone were hanging back waiting for something to take place which would restore prosperity to the industry; but so far nothing has made its appearance. Despite all, there is an optimism that the day is not far distant when a buying movement will set in. Meantime there is very little fresh business being booked, and inquiries are also extremely limited. Active conditions continue in the black sheet trade and a few further lots have been fixed up this week. Most of the dealings are, however, in galvanised sorts, the demand from Colonial buyers being prominent. Home prices are unchanged generally, but it is understood that sellers would be quite prepared to make concessions should anything in the way of a good tonnage be offered. The following are the current market quotations: Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{1}{4}$ to $\frac{1}{2}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Business in the West of Scotland malleable iron trade is still very slow and little change has taken place over last week. The prevailing conditions are of such uncertainty that the future almost seems a nightmare. Not only is there practically no demand for bar iron but the re-rolled steel branch of the industry, although a shade better, is likewise very quiet. Prices keep steady and "Crown" bars are still quoted at 12*l.* 10*s.* per ton delivered Glasgow stations.

Scottish Pig-Iron Trade.—A dull tone is all too general in the Scottish pig-iron trade, and only a very limited amount of business is going through. There is little demand on home account because of the general slackness of trade, but foreign inquiries show a slight increase this week. The output of the few furnaces now in blast, coupled with the stocks on hand, is quite equal to all demands. Prices are the turn easier again, although, nominally, unchanged, as under:—Hematite, 4*l.* 16*s.* 3*d.* per ton, delivered at the steel works; foundry iron No. 1, 4*l.* 18*s.* 9*d.* per ton, and No. 3, 4*l.* 13*s.* 9*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, August 16, only amounted to 525 tons. Of the total, 520 tons went overseas and 5 tons went coastwise. For the corresponding week of last year the figures were 1,090 tons foreign and 744 tons coastwise, making a total shipment of 1,834 tons.

Shipbuilding.—Shipbuilding orders are again very scarce and few have been reported during recent weeks. Messrs. William Simons and Company (Limited), Renfrew, have received an order from the Glasgow Corporation to build a new sludge steamer. This vessel will cost over 48,000*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—To-morrow the pits of the Cambrian Coal Company, at Clydach Vale, are to close down because of the unremunerative trading position. About 3,000 men will be rendered idle, and the weekly Welsh coal output will be lowered by about 13,000 tons. This drastic step has been taken by the managers because of the high cost of production and the impossibility, under present conditions, of making expenses meet revenue. As a result of the closing of pits and numerous stoppages, available supplies of coal are not so freely offered as has been the case for some weeks past, and prices have developed steadiness, while the best grades are firm, and in short supply. Arrivals at the docks have been restricted, and, owing to slow loading, betwene 20 and 30 vessels are waiting for berths. Best Admiralty large rules from 28*s.* 6*d.* to 29*s.* with seconds round 27*s.* 6*d.* and Monmouthshires from 25*s.* to 26*s.* 6*d.* Best smalls command 17*s.* 6*d.*, and good bunker qualities round 16*s.* Exports of coal as cargo from South Wales seaports in July, amounted to 2,298,642 tons, valued at 2,911,093*l.* or 25*s.* 4*d.* per ton. Compared with June, when there were five less working days, the July figures show an increase in volume of 401,090 tons, and in value of 532,688*l.*, while the average price per ton is raised by 3*d.* Shipments of large coal amounted to 1,579,815 tons valued at 2,211,934*l.* or 28*s.* per ton, which is 2*d.* less than in June; exports of through coal to 39,971 tons, valued at 40,792*l.* or 20*s.* 6*d.* per ton, an increase of 6*d.*; while small amounted to 678,856 tons, valued at 658,367*l.* or 19*s.* 5*d.* per ton, an advance of 2*d.* The volume and value of the shipments from the different ports were as follow:—

From		Tons.	£	Per ton.
Cardiff...	...	1,432,131	1,778,459	24/10
Newport	...	364,048	451,722	24/9
Port Talbot	...	214,815	254,196	23/7
Swansea	...	287,648	426,716	29/8

Shipments were increased at each port, and though the average price was advanced at Cardiff and Port Talbot by 6*d.* and 7*d.* per ton, respectively, at Newport and Swansea it was reduced by 1*d.* and 4*d.* respectively.

UNITED STATES NAVAL CONSTRUCTION.—On July 17, the new submarine V.1 was launched at the Navy Yard, Portsmouth, North Carolina. Her characteristics are: Displacement, 2,114 tons; horse-power, 6,500; surface speed, 21 knots; submerged speed 9 knots; length, 334 ft. Armament: One 5 in., one 3 in. (anti-aircraft) gun and six 21-in. torpedo tubes.

THE CITY AND GUILDS OF LONDON INSTITUTE.—The report of the Council of this Institute draws attention to the fact that, owing to the action of the Treasury, it has been necessary materially to reduce the budget of the Imperial College of Science. This has been effected by reducing the salaries of professors, by not filling up certain vacancies, by postponing certain developments, and by cutting down expenses generally, inclusive of the pay of some grades of the laboratory and administration staffs. In this way a saving of 8,000*l.* has been effected. On the other hand, the Clothworkers' Company have generously promised a grant of 3,000*l.* for five years. The number of students taking the City and Guilds diploma course was 410, and there were, in addition, 42 men following advanced or post-graduate courses. A considerable proportion of the students take the London University examination for the degree of B.Sc. (Engineering), and, as indicative of the relative difficulty of this examination and that for the college diploma, it is stated that 11 students who failed in the latter succeeded in securing the B.Sc. degree. The report announces that, owing to the decision of the London County Council to withdraw its financial assistance, it will be necessary to close Finsbury Technical College in 1926.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—Several new publications of the Association have recently come to hand, that numbered 5001—1924, dealing with "British Standard Dimensions for Valves for Pneumatic Tyres." The 10 mm. and 12 mm. plug and single-piece valves, common to cars in America, on the Continent, and in our own country, are completely specified by means of fully-dimensioned illustrations. Publication No. 5013—1924, headed "Pneumatic Tyre Rims," is in two parts, the first dealing with "Rims for Automobiles," and the second with "Rims for Motor Cycles and Cycles, including Side-cars and Carriers." This Report supersedes No. 70—1915 and Interim Report C.L. 8564—1920. Several modifications appear. The lip of the rim has been rounded off to avoid cutting the beads of the tyres. The marking of the rims has been changed, and sections of every rim are reproduced with dimensions and tolerances. Useful tables of sizes are included. Specification 206—1924, "Silver Solder Grades A and B" covers two grades of silver solder, the silver content in Grade A being between 60 and 62 per cent., and, in grade B, between 42 and 44 per cent. "Special Brass Ingots for Castings" is the title of Publication No. 207—1924, while No. 208—1924 relates to "Special Brass Castings." These publications cover the same five grades of materials which are classified according to their minimum tensile strength, ranging from 28 to 45 tons per sq. in. The copper content of each class is specified, a maximum total percentage only being given for metals other than copper and zinc, *i.e.*, tin, iron, manganese, aluminium and nickel. Copies of the specifications may be obtained from the B.E.S.A., Publications Department, 28, Victoria Street, Westminster, S.W.1, price 1*s.* 2*d.* each, post free.

THE CABLE-HANDLING MACHINERY OF THE "EDOUARD SUENSON."

CONSTRUCTED BY MESSRS. JOHNSON AND PHILLIPS, LIMITED, ENGINEERS, CHARLTON, LONDON.

(*For Description, see Page* 269.)

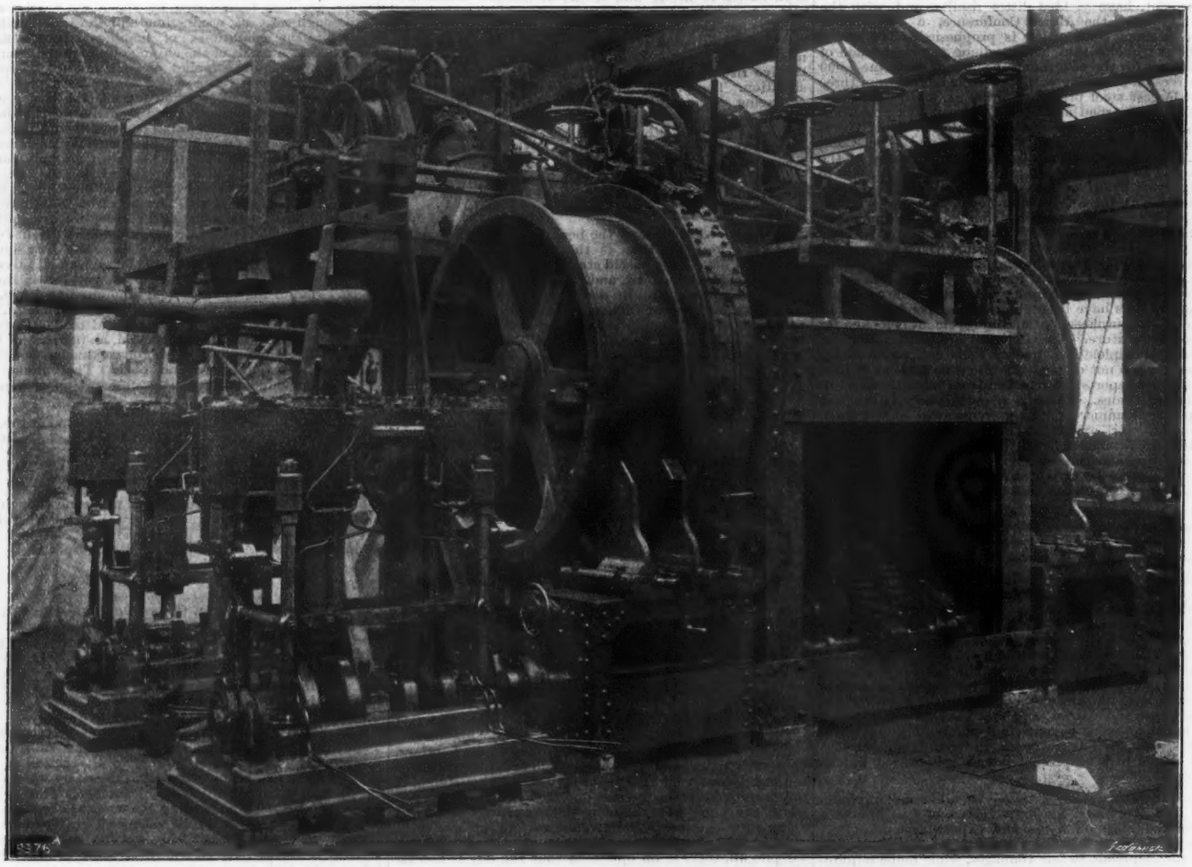


Fig. 14. General View of Picking-Up and Paying-Out Machine and Engines.

Tenders.—It is announced that a call for tenders for the supply of a complete installation of filters for treating 5½ million gallons of water a day of 24 hours has been made in connection with the Vaal River scheme. Tenders endorsed "Contract No. 260—Tender for Filter Plant," must be delivered at Johannesburg before noon on Friday, October 3, 1924, and must be accompanied by a certificate cheque or cash deposit of 200*l*. United Kingdom firms desiring further particulars should apply to the Department of Overseas Trade, 35, Old Queen-street, S.W.1, quoting reference A.X. 1241.

The Thomas Gas Meter: Errata.—In connection with the description of the above instrument, on page 182 of our issue of August 1, the sentence commencing at line 11 in the second column should have read:—"The galvanometer serves to indicate when there is a balance, which condition can be obtained by means of a suitable resistance, termed the temperature difference coil, in series with the inlet thermometer. The sentence commencing at line 3, on page 183, viz.: "This is accomplished in the instrument automatically by the nickel and manganese thermometers upsetting the bridge balance when too much water vapour is carried in the gas," should have read: "This is accomplished in the instrument automatically by means of the nickel thermometers and the temperature-difference coil."

The West Yorkshire Metallurgical Society.—The general meetings of the Society will be held during the ensuing session on the first Tuesday in each month at the George Hotel, Huddersfield, at 7.30 p.m., the annual general meeting taking place on Tuesday, October 7. Discussions will be arranged on the following subjects:—November 4.—"The Influence of Casting Temperatures on the Physical Properties of Non-Ferrous Alloys." December 2.—"The Corrosion of Engineering Materials." January 6, 1925.—"The Value of Some Workshop and Laboratory Tests." February 3.—"The Usefulness of Various Types of Metallurgical Furnaces." March 3.—"The Connection Between the Microstructure and the Mechanical Properties of Metals and Alloys." April 7.—"The Selection of Iron by Fracture and Chemical Analysis." Conjoint meetings with other Societies may also be arranged. Details of these and of any other functions will be announced in due course.

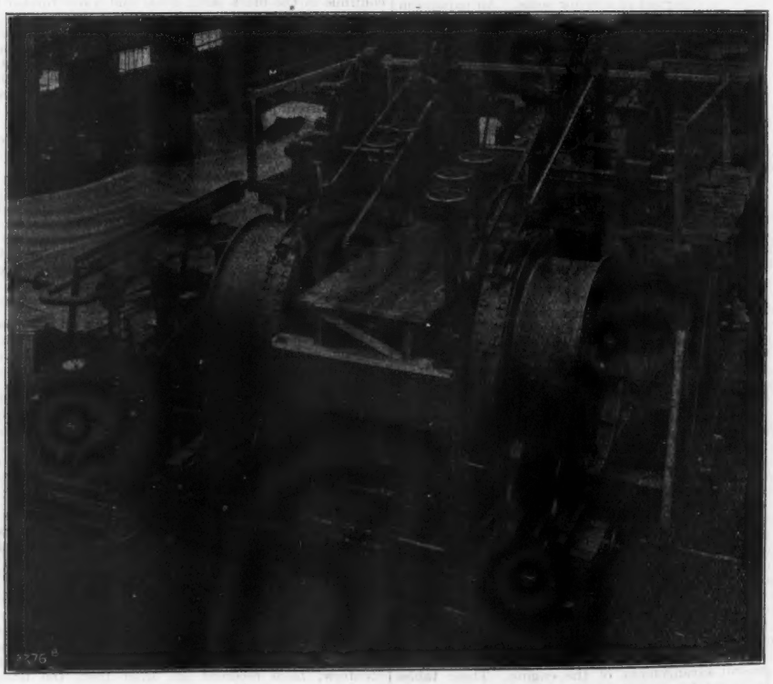


Fig. 15. View of Picking-Up and Paying-Out Machine from Above.

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 247.)

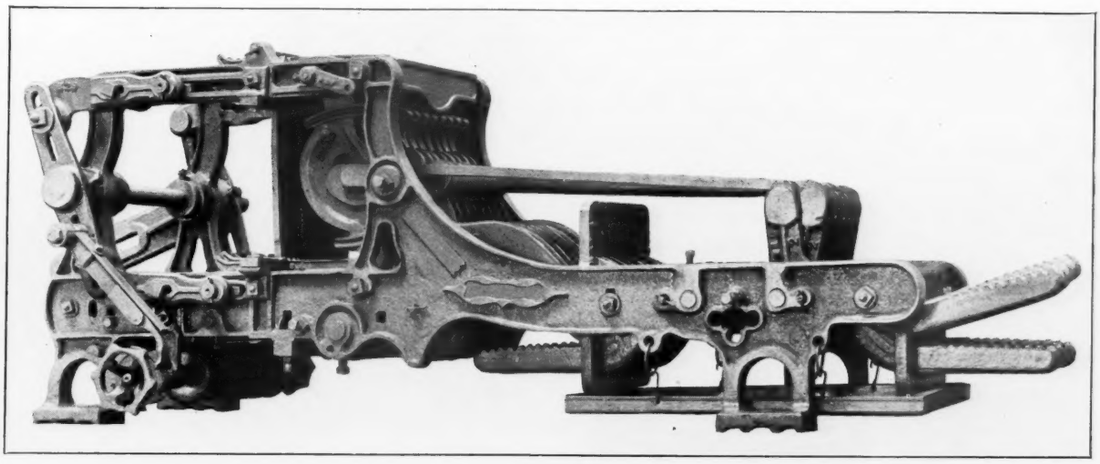


Fig. 29. Nelson No. 3 Dobby; Messrs. James Hill and Sons (Keighley), Limited, Keighley.

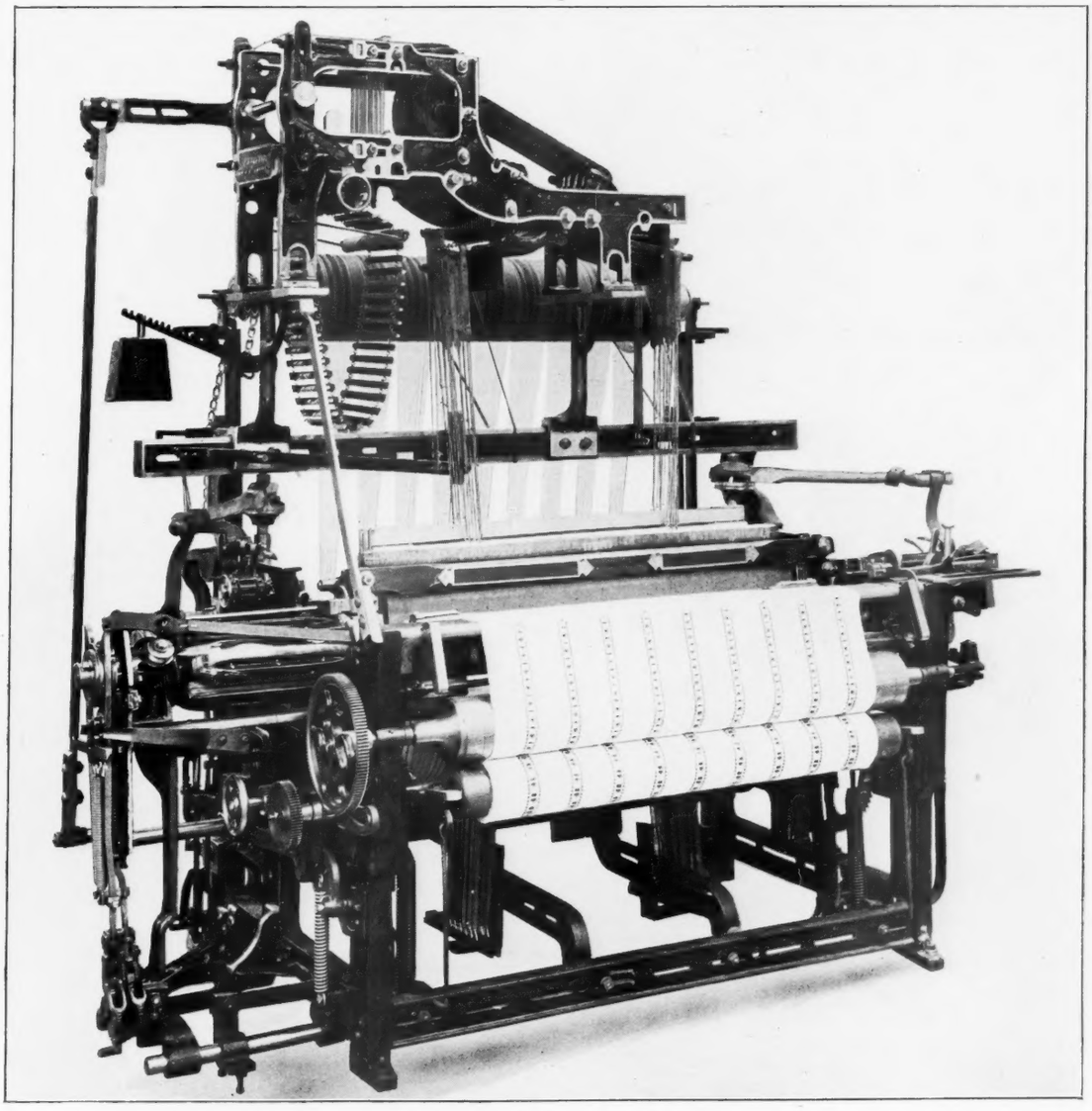


Fig. 30. Loom for Making Fancy Dress Goods; Messrs. W. B. White and Sons, Limited, Colne.

(*To face page* 248.)

TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION.

(*For Description, see Page* 247.)

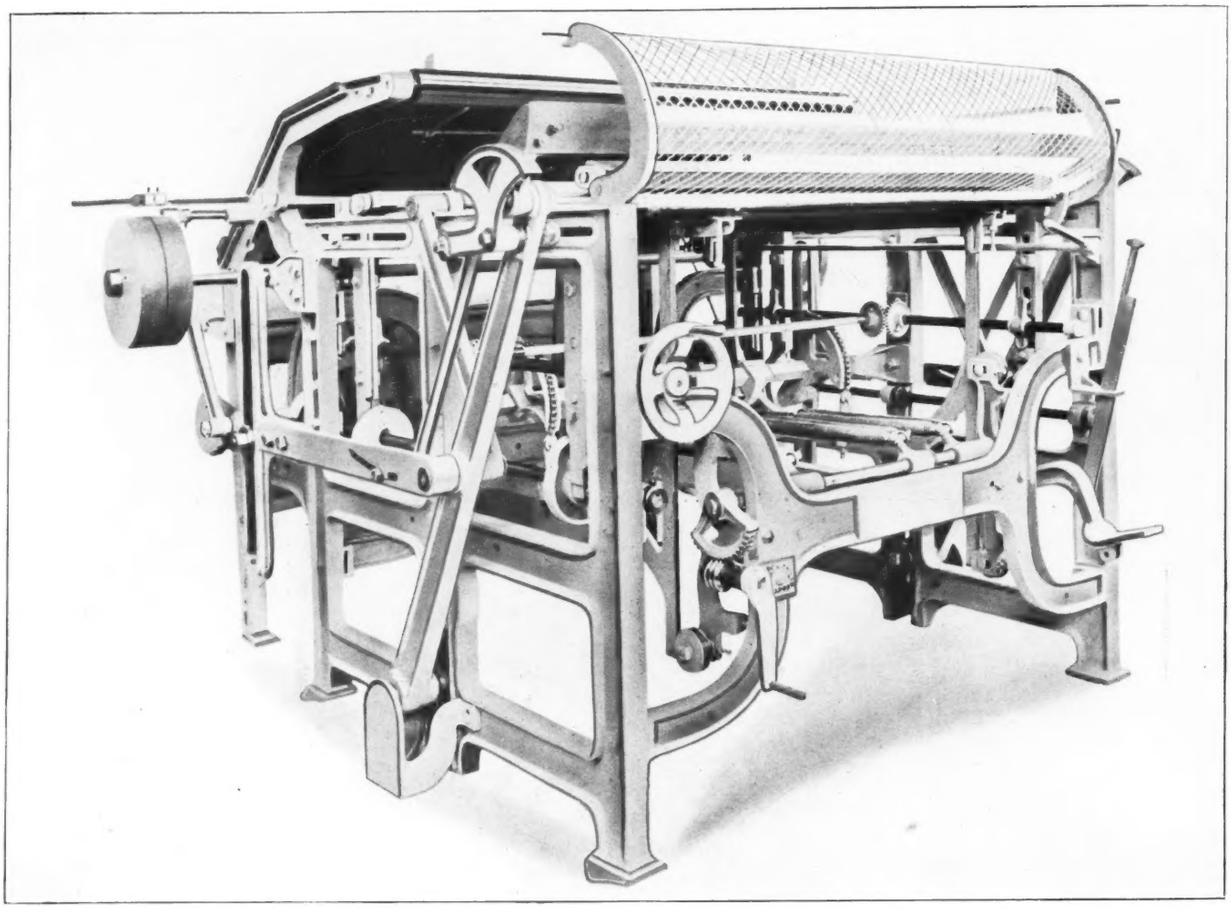


Fig. 31. Folding and Measuring Machine; Messrs. Hacking and Co., Limited, Bury.

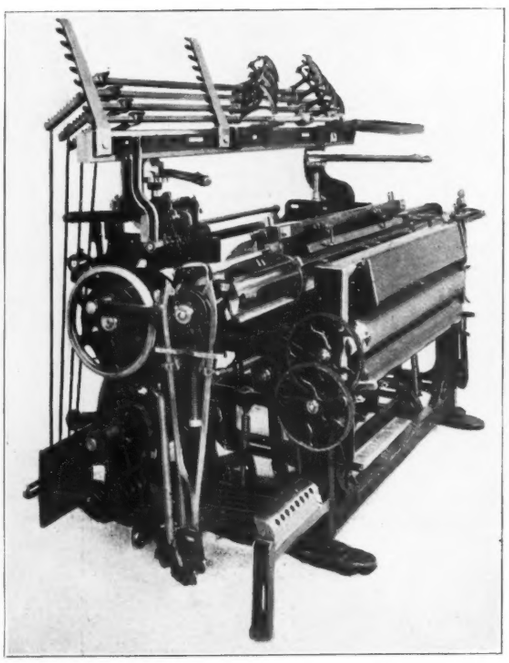


Fig. 32. Circular Box Loom; Messrs. David Sowden and Sons, Limited, Shipley.

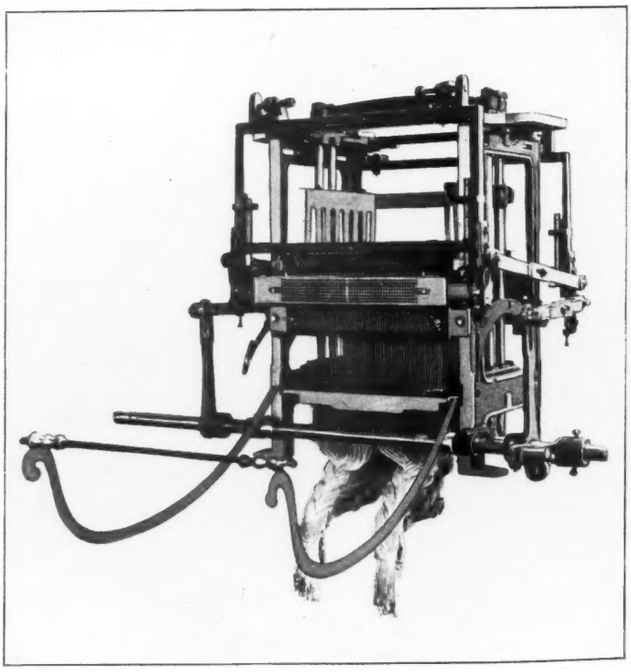


Fig. 33. Jacquard Machine; Messrs. Richardson, Tuer and Co., Limited, Farnworth.

THE QUEENSTON-CHIPPAWA WATER POWER DEVELOPMENT.

MR. F. A. GABY, CHIEF ENGINEER OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO.

(*For Description, see Page* 255.)

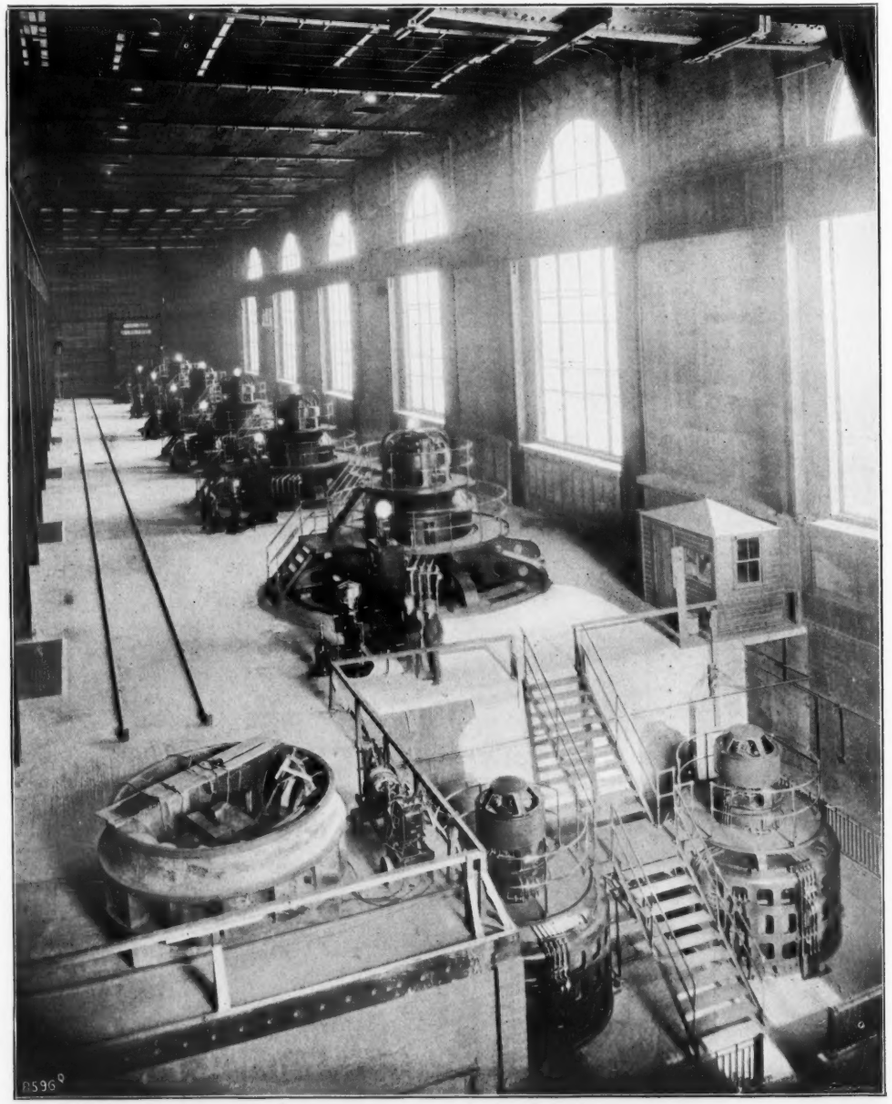


FIG. 20. INTERIOR OF GENERATOR ROOM LOOKING NORTH.

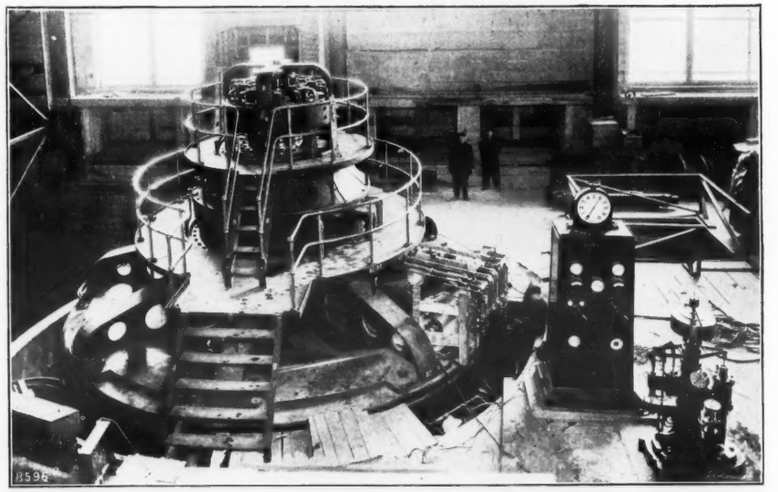


FIG. 21. NO. 2, GENERATOR SHOWING CONTROL PEDESTAL.

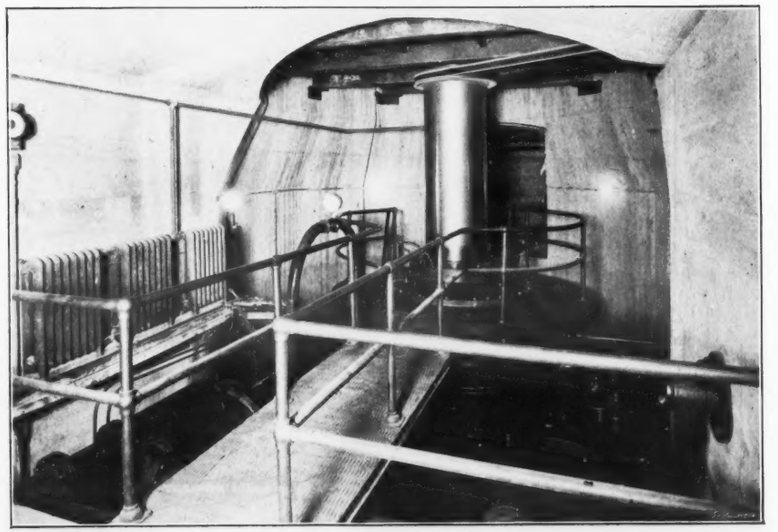


FIG. 22. PASSAGE WAY TO TURBINE GLANDS.

(*To face page* 256.)

REINFORCED CONCRETE BRIDGE OVER THE SALMON RIVER, PULASKI, N.Y.

(*For Description, see Page* 257.)

Fig. 1. General View of Completed Bridge.

Fig. 2. View Showing Centring used for Arch.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shilings for the first four lines, or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

AGENTS FOR "ENGINEERING."

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CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., Limited, Rose-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque For Advertisements, Office de Publications Commerciales 167 Rue Montmartre, Paris (2e).

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INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

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NORWAY, Christiania Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son, Limited.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons (South Africa), Limited, 29, Long-street, Capetown.

TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart

UNITED STATES: For Subscription, New York: W. H. Wiley 440, Fourth Avenue. For Advertisements: J. S. Allan 30, Church-street, New York.

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Four One-Page Plates.—TEXTILE MACHINERY AT THE BRITISH EMPIRE EXHIBITION. THE QUEENSTON-CHIPPAWA WATER POWER DEVELOPMENT. REINFORCED CONCRETE BRIDGE OVER THE SALMON RIVER, PULASKI, N.Y.

ENGINEERING.

FRIDAY, AUGUST 22, 1924.

SYNTHETIC NITROGEN PRODUCTS.

THE recent action of the French Senate in connection with an agreement with the Badische Anilin and Soda Fabrik (B.A.S.F.) for the manufacture of synthetic ammonia by the Haber process, and the announcement in the House of Commons that similar action was being taken by the British Government, once again directs attention to a vital national problem which should not be crowded out from a very full programme of industrial and political problems.

Nitrogen products in the form of Chilian nitrate, ammonium sulphate from gas-works, and in various synthetic forms, such as ammonia, calcium cyanamide, and nitrate of lime, are of primary importance from the two-fold point of view of food production and the manufacture of munitions, and no lesson of the war was more emphatically taken to heart than this—at least for a time. But memories are short, or have a great deal else to occupy them. Among the innumerable committees set up during and immediately after the war, one of the most important, and one which, it may be added, did its work in a very thorough and convincing manner, was the Nitrogen Products Committee, which published its final report in 1920 (Cmd. 482). This voluminous report of over 300 foolscap pages is a mine of invaluable information, and deserves a better fate than the pigeon-holes of dusty oblivion. It should be taken down from remote shelves and be very carefully re-studied in the light of recent developments.

Before the war the world's supplies of nitrogenous substances, mainly for agricultural purposes and to a less extent for the manufacture of nitric acid, were available in the form of sodium nitrate from Chili (2,500,000 tons) and ammonium sulphate from gas-works and coke ovens (1,300,000 tons). Synthetic products in the form of calcium cyanamide from Norway and synthetic ammonia from Germany accounted for 170,000 tons. During the war, Germany's imports of about 800,000 tons per annum of Chilian nitrate dropped to zero whilst her production of synthetic ammonia by the Haber-Bosch process developed to an amazing extent.

Briefly, the Haber process consists in the direct synthesis of ammonia by combining its elements, nitrogen and hydrogen, under pressure and heat, in the presence of a catalyst. About 77,000 cub. ft. of hydrogen and 26,000 cub. ft. of nitrogen are required per ton of ammonia, allowing for losses. The nitrogen is easily obtained by distilling liquefied air, and is a comparatively unimportant item of cost; but the cost of the hydrogen is a dominating factor, and the success of the whole business turns on the production of pure and cheap hydrogen. It is hoped to get the cost down to something like 2*s.* 6*d.* per 1,000 cub. ft., which means that the total cost of ammonium sulphate will work out at about 6*l.* per ton. This is less than half the current price to-day, and the estimate appears at present rather optimistic. Yet the Haber process has proved so successful on a commercial scale, and its possibilities are so great that there seems little reason to doubt that the synthetic product, already a keen competitor, may soon dominate the world markets and control prices. The supply of the necessary raw materials, nitrogen and hydrogen, is practically unlimited, at least in regard to the nitrogen, of which there are 20,000,000 tons in the atmosphere over each square mile of the earth's surface. The hydrogen, for the production of which there are numerous processes, is chiefly obtained either from the water-gas of coke ovens, or from the electrolysis of water.

In the debate on the French agreement with the B.A.S.F., it was stated that Germany would soon be in a position to manufacture 500,000 tons of synthetic nitrogen products per annum, and she was aiming at an annual output of 800,000 tons. By means of its agreement with the German firm, which merely seems to be a consummation of the rights granted to France under the Treaty of Versailles, it is hoped that France will be able to ensure a supply of 100,000 tons of nitrogen, or about 500,000 tons of nitrogen products, per annum, sufficient, with nitrogen from other sources, to meet her agricultural needs and allow a safe margin for possible military contingencies. In 1913, France imported about 350,000 tons of Chilian nitrate, and produced from her own gas-works and coke-ovens about 74,000 tons of ammonium sulphate. Germany's pre-war consumption of ammonium sulphate was 460,000 tons.

There has been considerable controversy in France and elsewhere as to the respective merits of the Haber and the Claude processes. At one time it seemed that the latter, *i.e.*, the French process, was far superior to the other, especially since, owing to the enormous pressures used—up to 1,000 atmospheres—much smaller and simpler plant could be used, giving higher yields. The official attitude in France, so far as it was revealed in the discussion of the Badische agreement, seems to be that it is well to have two strings to one's bow, and that the official adoption of the Haber-Bosch process, with the assistance of German chemists and engineers, does nor exclude the development of other methods, notably that of Georges Claude. Certainly, the Claude process has made considerable progress the last few years, and several plants on a commercial scale have been erected in France and abroad, chiefly in connection with the coke oven industry. There is one at Bethune in Northern France, which has been producing ammonia at the rate of 3 tons per day for the last two or three years; and is about to be extended to produce 30 tons daily. The Claude plant at Montereau has a daily output of 5 tons ammonia, and other plants are being erected at St. Etienne, Décazeville, and at the Aniche colliery. There are also plants at Barcelona yielding 2 tons of ammonia per day, with extensions in hand to bring it up to 10 tons a day; in Belgium, making 20 tons per day, using coke-oven hydrogen; in Italy, at Brussi, using electrolytic hydrogen, and making 10 tons per day; and in Japan several Claude plants are in course of erection.

In Germany and France, therefore, synthetic nitrogen products are being manufactured on a large commercial scale; and in Norway also calcium cyanamide and other synthetic products have been manufactured for many years from atmospheric nitrogen, using the electric arc and

other processes and the cheap electrolytic hydrogen rendered possible by the enormous supplies of available water power.* In France, too, increasing attention is being given to the important question of determining what is the best form in which nitrogen should be used as a fertiliser—a problem of great interest which has for many years formed the subject of experiments at Rothamsted.

In the United States of America, although no very tangible results have yet been recorded and attention has been distracted by the political squabbles over Muscle Shoals, some keen research work is being carried out at the Fixed Nitrogen Research Institute, under the direction of Dr. F. G. Cottrell. In his annual report for the year ended June 30, 1923, Dr. Cottrell seems to be concentrating attention on the discovery of a more efficient catalyst, and it is understood that remarkable success has lately been achieved in this direction. The American demand for nitrogenous fertilisers is estimated at 1,000,000 tons per annum. The capacity of the Muscle Shoals plant, which Mr. Ford may possibly soon take over, is about 40,000 tons of nitrogen per annum. If the price of fertiliser were low enough—and great hopes are entertained that the various synthetic methods will ultimately bring the price down—there is practically no limit to the amount that could be used.

Dr. Jacob Lipman, of the New Jersey Agricultural Experimental Station, has estimated that the annual loss of nitrogen from all land under cultivation in the United States of America not replaced by manure, by ploughing in leguminous plants, by atmospheric precipitation in the form of rain and snow, and by the present use of commercial fertiliser, amounts to approximately 3,500,000 tons of nitrogen, equivalent to about 17,500,000 tons of ammonium sulphate. Over a great part of the world very little fertiliser, if any, is used, and the potential demand for a cheap supply is indeed nearly unlimited.

What is the nitrogen position in this country? In view of its vital importance and of the excellent work done by the Nitrogen Products Committee, the practical results are disappointing and appear to be very near to zero. It is true that a large British firm a few years ago sent a commission to the Continent to study the Claude and other processes, decided in favour of the Haber process, and took over the Government factory at Billingham, to be run by an associate company, Synthetic Ammonia and Nitrates, Limited, where it was hoped that at least 10,000 tons of ammonia per annum might be produced. At the last annual meeting of the British firm in question the progress and prospects of this associate company were discussed, but nothing very definite is known. The veil of obscurity was temporarily drawn aside in the House of Commons recently, when, in reply to questions about the Franco-German agreement, Mr. Stephen Walsh said that similar steps had been taken by the British Government in conjunction with a British firm. It is understood that the first large unit is now working at Billingham, producing 100 tons ammonium sulphate per day, and that plant for the manufacture of nitrate is being erected. Further light on the subject is required.

There is not the slightest doubt that British scientists have been among the leading pioneers in this vitally important and comparatively new industry; but, as was the case with the dye industry, Germany was allowed to reap the fruits of British inventions. In the arc process, the oldest method of fixing nitrogen, the Birkeland and Eyde electric furnace is used. Air is burnt by passing through an intensely hot electric flame consisting of a powerful arc spread out by a magnetic field into a circular form several yards in diameter. Professor Birkeland himself has frequently acknowledged his debt to Sir William Crooke's famous presidential address before the British Association, and to the experimental work of the late Lord Rayleigh. These brilliant ideas and suggestions were not worked up in this country, but in Norway and Germany. The latter country has doubled her cyanamide (arc process) plant at Piesteritz, and it is possible that the latest developments may enable this particular fixation process to supersede all others, including the Haber-Bosch process. It has always been the cheapest, especially with abundant water power available, and the possibility of manufacturing urea direct would be a tremendous advance. Independent workers in Sweden and Switzerland a year or two ago succeeded in perfecting a process whereby free cyanide is prepared by the action of carbon dioxide on calcium cyanamide, and is subsequently converted into urea. In the Swiss process excess of the sulphuric acid employed in the second part of the transformation is used to act on phosphate rock which is thus changed to mono-calcium phosphate, the final product being a neutral body known as phosphazote, a double fertiliser of phosphorus and nitrogen.

Meanwhile the Haber process has proved very successful in Germany. In the French debate on the proposed agreement it was, as already pointed out, stated that the German output was already 500,000 tons of nitrogen products; but, according to Dr. Harker, who gave an interesting review of the whole subject before the British Association at Hull in 1922, the German capacity, even then, was 500,000 tons of *nitrogen* per annum, which means approximately 2,500,000 tons of nitrogen compound in the form of ammonium sulphate. In several papers and discussions on the subject the weights of nitrogen only and of nitrogen compounds have been confused, and it is necessary to distinguish very carefully between the two. In the Haber process, as in the arc process, English workers have played an important part. Among those of Haber's collaborators who had much to do with the original invention were Dr. Le Rossignol, an Englishman born in Jersey, and the late Dr. H. C. Greenwood, the brilliant young scientist whose early death was universally deplored in the scientific world. Some very valuable and important research work was undertaken in the laboratories of the Nitrogen Products Committee, and in some respects, *e.g.*, in gas velocities and yields of ammonia, the Haber process was much improved upon. In view of all this work, the results of which appear to be hidden away in blue books, and of the early pioneer work of British scientists, it is amazing that this country has not played a much more important part in later developments than has so far been apparent. It is a matter of the greatest interest to British chemists and engineers and of first-rate importance to the whole Empire.

* Norwegian exports of nitrate increased from 71,000 tons in 1913 to 147,000 tons in 1923. The industry was growing rapidly, but is now suffering a temporary check.

PATENT NOVELTY.

In order that a patent may be valid it must possess the element of novelty. Novelty in different countries has different definitions. In this country it means novelty within the realm. Publication of the invention abroad before the date of the British application does not invalidate a British patent. On the other hand publication by way of a foreign specification reaching this country before the date of the British application does detract from the novelty of the British case. There are certain specific exceptions to lack of novelty provided by the Patent Act. A British specification more than fifty years old of itself will not invalidate a British patent, and it is possible therefore to re-patent something described in a specification more than fifty years old if that be the only publication of the alleged invention. Very little has been done in the way of defining just what is required in addition to the specification more than fifty years old to enable it to invalidate a later patent.

In a case not long ago before the courts the judge granted a certificate of costs in respect to a specification more than fifty years old, thereby practically admitting it, his reason presumably being so far as one can ascertain from the reports, that examples of manufacture according to the specification or on somewhat similar lines had been seen in museums.

A provisional specification which has been printed, but not followed by a complete specification is not at the present day considered to be such a publication as will detract from the novelty of a later application. A specification for the same invention by the same inventor filed abroad, accepted and sent to this country before the British application is lodged will not bar the grant of a valid British patent provided that the British application is lodged under the provisions of the International Convention for the protection of industrial property. According to this the British application must be filed within one year of the filing of the first application foreign to this country. If not filed under the provisions of this convention the British patent in the circumstances mentioned would be invalid having no novelty in view of the prior publication.

Publication of an invention at an exhibition does not detract from novelty if certain conditions are fulfilled. These are dealt with in Section 45 of the Act of 1907. This section has been amended by the Act of 1919, so that it now covers in addition the reading of a paper by an inventor before a learned society or the publication of the paper in the society's transactions. The first part of the section as it now stands reads as follows:—

"The exhibition of an invention at an industrial or international exhibition, certified as such by the Board of Trade, or the publication of any description of the invention during the period of the holding of the exhibition, or the use of the invention for the purpose of the exhibition in the place where the exhibition is held, or the use of the invention during the period of the holding of the exhibition by any person elsewhere, without the privity or consent of the inventor, or the reading of a paper by an inventor before a learned society, or the publication of the paper in the society's transactions, shall not prejudice the right of the inventor to apply for and obtain a patent in respect of the invention or the validity of any patent granted on the application, provided that—

"(*a*) The exhibitor, before exhibiting the invention, or the person reading such paper or permitting such publication, gives the comptroller the prescribed notice of his intention to do so; and

"(*b*) The application for a patent is made before or within six months from the date of the opening of the exhibition or the reading or publication of such paper."

By Order in Council this section may extend to any specifically mentioned exhibition, and such order may relieve the exhibitor from the condition of giving notice to the Comptroller.

It is important to notice the practice under this section in respect of papers read before a learned society. This is provided for by a rule according to which the inventor must give notice to the Comptroller setting out the date when the paper is to be read, and stating that he intends to publish his invention by reading the paper or by permitting publication in the society's transactions. A brief description of the invention has to be appended, and this should be accompanied by drawings if necessary.

The new Act also provides that prior publication shall not invalidate a patent under certain circumstances in the sense that the court may now grant relief in respect of individual claims. Prior to the Act of 1919, if one claim were invalid on the ground of lack of novelty or, indeed, on any other ground, it would vitiate the whole patent. The Act of 1919, in Section 9 provides that the Court may grant relief in respect of such claims as are infringed if they find these claims valid without regard to the invalidity of any other claim. Prior publication therefore of matters claimed in one claim, but not claimed in another, is not such a publication as will necessarily invalidate the patent as a whole.

Subject to the above remarks a patent may lack novelty if what it claims has already been published in a British specification prior to the date of the patent or a foreign specification freely available in this country or any other publication in the technical or non-technical press to which the public have reasonable access. In addition, use of the invention in such a way as to effect publicity, that is to say, prior public user will also invalidate. In some instances brief descriptions are available by way of the abridgments of foreign patents received in this country before applications are filed here not under the provisions of the International Convention. This occasionally happens in the case of inventions originating in the United States of America. An

American inventor may wait for the issue of his American patent before filing his British application, omitting to bear in mind that the American *Official Gazette* containing the claims of his patent is received in this country very shortly after the grant of the United States patent, and this publication may well be sufficient to invalidate the grant of a subsequent British application.

The question of publication is always one of fact, namely, does the prior material disclose what the patent claims. In practice, however, only in very rare instances is a patentee confronted with the exact invention described in some prior material. More often something like it is found, and the suggestion is thereupon made that the difference does not constitute an invention or involves what is termed no subject-matter.

There is one other case of disclosure before a patent has been applied for, which will not invalidate the patent that should be noted, namely, disclosure involving a breach of confidence. This is governed by Section 41 of the Act of 1907, Section 2 of which reads as follows :—

"A patent shall not be held to be invalid by reason of the invention in respect of which the patent was granted, or any part thereof, having been published prior to the date of the patent, if the patentee proves to the satisfaction of the court that the publication was made without his knowledge and consent, and that the matter published was derived or obtained from him, and, if he learnt of the publication before the date of his application for the patent, that he applied for and obtained protection for his invention with all reasonable diligence after learning of the publication."

An important addition has been made by means of the Act of 1919 in the form of a proviso, namely, the protection afforded by this sub-section shall not extend to a patentee who has commercially worked his invention in the United Kingdom otherwise than for the purpose of reasonable trial of the invention prior to the application for the patent.

SOME PROBLEMS IN SHIPPING AND SHIPBUILDING.

WHILE a launch must ever be an impressive spectacle, experience and the formulation of the factors associated with the movement of a great mass on the ways from the shipbuilding berth to the water have made success a certainty. Such an event, however, has on many occasions led to a clear statement of scientific or economic problems associated with shipping and shipbuilding. A typical example of this occurred during the proceedings at a luncheon which followed the launch of the new Orient liner Oronsay at the Clydebank shipyard of Messrs. John Brown and Co. on the 14th inst. When there are present such authorities on transport as Sir Kenneth Anderson, Sir Allan Anderson and Sir John Beale, who are responsible for the management of the Orient Line, and such eminent authorities on shipbuilding economics and construction as Sir Charles E. Ellis and Sir Thomas Bell, and particularly when they are willing to speak on the subject they have made specially their own, it necessarily follows that the true facts of the present situation as regards probably our two greatest industries, are enunciated. This is useful at the present time of extreme uncertainty, and the speeches delivered were illuminating, if not cheering.

Sir Kenneth Anderson, who, viewing the situation from the point of view of shipping, was quite accurate in stating that the present depression in the shipping industry was the longest in the memory of man; but the fact that the Orient Company have now in various stages of construction three of the largest steamships that have ever been engaged in mail and passenger service from this country to Australia, gives encouragement to the view that this long depression may soon pass away. As he said, the management of the Orient Line, by their policy, have disclosed their faith in the future. Not only is the Oronsay of a gross tonnage of 20,000, but she has single-reduction Brown-Curtis turbine machinery of 20,000 h.p., which, it is anticipated, will give the vessel a speed unprecedented in the Australian service. The problem in all ships is to ensure the maximum number of single-berth cabins and natural ventilation, however much this may be assisted by the circulation by fans of the air, either heated or cooled, and in these three new Orient liners there are arranged on each side of the ship three rows of cabins, the outer having its direct porthole; the next and the third have connection through passage-ways to port-holes. The proportion of single-berth cabins to the total is greater than on any other ship. A feature, too, is that only first-class and steerage passengers are carried. As to the other features of the ships and their machinery, we hope to deal in detail with one of these new Orient liners at an early date.

The economic side of shipbuilding was dealt with by Sir Thomas Bell, who, in characteristic sympathy with working men, spoke of the great disparity in the remuneration of skilled workers and the wages paid to unskilled employees in the sheltered trades. This is a problem which is most disturbing to all responsible for the employment of trained workers, but it is easier to realise the difficulty than to find a satisfactory solution. There is no doubt that the disparity to which we have referred leads to a great measure of discontent, and the sooner, in the interests of the country, we get to a realisation of the sound economic doctrine that remuneration must be determined by the value of the labour product, the better it will be for the whole nation, and especially for the working men, because the expenditure for work in sheltered trades necessarily increases the cost of living, and therefore affects directly the value of the wage to all. Sir Thomas did not attempt to provide the remedy, but pleaded for some increase in the volume of work done, with a resultant augmentation of the earnings of the workers. Thereby only could there be a greater output without any corresponding increase in the standing charges; indeed, with a maximum output the overall costs would be distributed over a greater area, and this would necessarily reduce the cost of production and make it easier to compete in home and foreign markets.

Perhaps, however, the greatest problem besetting the shipowner, possibly also the shipbuilder, is related to the use of the Diesel engine on board ship. It is not necessary here again to prove the success of the Diesel engine in moderate-powered vessels; as to the maximum power that is being fitted in any ship, there is a more or less convincing case, the Aorangi, which is now being completed on the Clyde with four sets of internal-combustion engines driving four screw propellers, and of a total of 13,000 shaft horse-power, so that the managing directors of the Orient Line who heard Sir Thomas Bell's interesting speech may have had justification for not adopting internal-combustion engines of 20,000 shaft horse-power on the Oronsay. The hesitancy of many shipowners, however, is not so much connected with the power justifiable in any given ship, but rather the potential supplies of oil fuel, and it was on this point that Sir Thomas was particularly convincing. He pointed out that, if it be assumed that the working time per annum for any ship was 240 days, then, on a moderate assumption in regard to fuel consumption, the conclusion was reached that one ton of oil per annum would provide a generous margin for the fuel consumption required for each gross ton of Diesel shipping. He was optimistic regarding the possible addition to the merchant tonnage dependent on oil consumed either in boiler furnaces for steam turbines or in internal-combustion engines. There was justification for his view that the Russian oil fields will come back to their pre-war working conditions, and, believing this, he felt that it was quite possible to find a supply of oil fuel for another 17 million tons of modern speed ships propelled by Diesel engines. This is a happy augury, because there is not the remotest doubt that at the present time Diesel-engined ships form the most economically successful part of the world's shipping industry.

SCHOLARSHIP.—A Goldsmid Engineering Entrance Scholarship of the value of 40*l.*, tenable for three years, is offered for competition at University College, London, in September, and is available for students taking the full degree course in engineering, beginning in October. Full particulars of the scholarship examination can be obtained from the Secretary of University College, Gower Street, London, W.C.1.

THE BRITISH ASSOCIATION MEETING AT TORONTO.

THE 92nd inaugural meeting of the British Association was held on Wednesday, August 6, in the Convocation Hall of the University of Toronto, one of the imposing group of colleges and residential halls which cover the extensive university grounds. The name "Toronto" is said to signify "a place of meeting"; Toronto, the capital of the province of Ontario, is the educational centre and the leading manufacturing town of Canada. The population, less than 10,000 in 1828, when the first college was founded, had risen to 200,000 by 1897, when the Association met there for the first time, and was 538,771 by the end of 1923. Apart from the last York meeting, at which the reception-room was in the beautiful Abbey grounds, the Association has hardly ever assembled in more impressive surroundings. There is ample space in the buildings for the Association as well as for the International Mathematical Congress, which was opened on Monday, August 11. All the buildings are within easy reach of one another and are separated only by avenues of trees and expansive lawns, the trees on which afford welcome shade.

Most of the members from the Old Country had made pleasant and fast crossings in spite of the cold and misty atmosphere. The Caronia, which brought the main party of 233 members from Liverpool to Quebec, had accomplished the journey within the record time of less than six days. The local committees, as well as the shipping and railway companies, did everything to spare members avoidable trouble in landing and in arriving with their luggage at their destinations.

As the excursions and entertainments commenced at Quebec and were continued at Montreal and Ottawa, and as members had the choice of various routes and retained, of course, their right of following their own plans and of changing their minds, that the attendance of many officials at piers, hotels, and railway stations was required. But all went well, though members grumbled at the warmth of the welcome by the sun of Toronto.

The proceedings of the inaugural meeting deviated in one respect—not inappropriately—from traditional lines. According to the old-established custom, the President, Sir Ernest Rutherford, would at once have risen to introduce his successor, Major-General Sir David Bruce, K.C.B., F.R.S., and the welcome by the Association would have been combined with the vote of thanks to the President. This year the welcome to the British Association came first; it was tendered by Sir Robert Falconer, President of the University of Toronto, on behalf of the University, by the Hon. Forbes Godfrey, M.D., on behalf of the Government of Ontario, and by Professor J. C. Fields, F.R.S., on behalf of the Royal Canadian Institute. Sir Ernest Rutherford then rose, and read a telegram addressed to himself by the Prince of Wales wishing the association a successful session and expressing the Prince's particular interest in one item to be discussed, viz., the educational training of boys and girls for life overseas. In introducing his successor, Sir Ernest remarked that the president-elect probably enjoyed unique distinction because his reputation had been made, not in the laboratory, but in the wilds of Central Africa.

THE PREVENTION OF DISEASE.

Sir David Bruce's presidential address on the "Prevention of Disease" was certainly not of less interest to the engineer and works manager than to the general public. Upwards of twenty million weeks of work were lost, he pointed out, every year through sickness, and that figure, which referred only to insured workers, showed the need of a change of medical strategy; instead of awaiting an attack, medicine must take the offensive. The practitioner should frequently examine the man while he was apparently well, and the public health authorities should see that the man's environments were in accordance with scientific teaching. The idea that microscopic creatures were the cause of infection had grown since the middle of the last century. Sir David distinguished three kinds of infectious germs, bacterial, protozoal, and

parasites still unknown, and so minute that they passed through the porcelain filters which the other germs could not traverse. Sometimes, the study of the nature of the germ enabled us to stop it reaching the victim; that was so in the case of the Malta fever, in the tracking down of which to the Malta goats and their milk, Sir David had had a prominent share. In other cases (typhoid, small-pox, &c.) prevention was secured by inoculation of the unattacked man with the virus in order to produce a slight attack followed by a period of immunity, or with the antitoxin (diphtheria and tetanus).

These diseases were of bacterial character. The protozoal diseases nagana, which killed cattle, and the sleeping sickness, required other means of prevention. Sir David, ably assisted, as Sir Ernest had mentioned, by his wife, had traced these illnesses to trepanosomer, blood parasites of the game of the jungle, which the bite of the tse-tse flies introduced into the victims. Prevention could be obtained and had been obtained by killing the game, by clearing the jungles and thus expelling the flies, and by removing the inhabitants from the fly belts. Malaria and yellow fever, also protozoal probably, had been eradicated by similar methods, by destroying the mosquito carrier. That might be possible also in the case of some of the still large group of undetermined diseases. Tuberculosis was a bacterial disease but also largely an "environment" disease, to be prevented by providing plenty of light, fresh air, good water and sanitary engineering generally. Sir David Bruce could only touch upon the most important work done by the engineer in preventing disease. Not all diseases are caused by living germs of course, and he had to dwell upon "deficiency" diseases and other features.

The vote of thanks was proposed by Prof. J. C. McLennan, F.R.S., chairman of the local executive committee for the Toronto meeting. Before the meeting dispersed, Mr. F. E. Smith, F.R.S., general secretary of the Association, announced, on behalf of the absent treasurer, Dr. E. H. Griffiths, that 2,457 members of all classes had entered their names, that number compared well with the attendances at the Montreal meeting of 1884 (1,977) and of the Toronto meeting of 1897 (1,362).

Canadian and American science were strongly represented, and the meeting is considered the most important general scientific gathering so far held on the American Continent. The discussions of the first day of sectional proceedings, Thursday, the 7th inst.—when these lines were written—quite justify the anticipation of a memorable meeting.

SECTION G.—ENGINEERING.

The Engineering Section assembled for their first meeting at 10 a.m., on Thursday, August 7, under the presidency of Professor G. W. O. Howe, who opened the proceedings by the delivery of his presidential address, entitled "A Hundred Years of Electrical Engineering." We reprinted a long abstract of this in our issue of August 8 last (page 190 *ante*). Professor Howe chose rather to enumerate the developments of electrical engineering generally during the last hundred years than to enlarge upon those particular branches of electrical science concerning which he could have spoken with special authority. There was, however, plenty of matter of historical interest in the address, and the reminder of Lord Kelvin's strong views as to the essential advantages of direct current over alternating current for power transmission was opportune in view of the recent invention of the transverter for producing direct current at exceedingly high voltages. In proposing a vote of thanks to the President, Dr. C. H. Mitchell, Dean of Toronto University, expressed the thought that must have occurred to every one who heard the address, namely, the debt which modern engineers owed to those early pioneers who by their experiments, guesses and deductions, laid the foundations of electrical engineering as we know it to-day. Dean Mitchell, in commenting upon the difficulty of accurate foresight, mentioned that after the war when the possibilities of wireless telephony were just becoming recognised, he had had a conversation with Mr. Marconi, whose most optimistic forecasts had fallen far short of the development which had since taken place. The vote of thanks was seconded by Professor C. F. Jenkin, who mentioned that his father was the secretary of the Committee of the British Association, which had established the now International Standard Electrical units, and had also been the engineer in charge of laying the first Atlantic cable, and closely associated with Lord Kelvin in some of his work. The speaker mentioned a private dinner given by Lord Kelvin to celebrate the installation of electric light in Kelvin's house. During the dinner the light went out and the meal was concluded by the aid of candles stuck in beer bottles, a resource which possibly would not be available in Ontario at the present time.

Railway Transportation in Canada.

In the unavoidable absence of Sir Henry Thornton, who was detained on business in the West, his paper on "Railway Transportation in Canada," was read by Mr. R. H. C. Henry, Vice-President of the Canadian National Railways. The paper, of which we hope to give an abstract later, was illustrated by large wall maps and lantern-slides. The ground covered was greater than the title indicates, as transportation by means of dog-trains, pack-horses and Hudson Bay wagons was also touched on. The wall maps illustrated the growth and extent of the Canadian railway system, a small inset map of Great Britain and its railways, to the same scale serving to emphasise the almost insignificant distances in Britain when compared with the immensity of the Canadian distances. One series of lantern slides showed the various stages in the journey of wheat from the Western farms to the grain ships which carried it across the ocean. Its first haul to the local elevators, its discharge into box-cars, the haul of long trains of such cars to the elevators at Port Arthur at the head of the lakes, the discharge into freighters, and its subsequent journey by one route or another to the terminal elevators at an ocean port, were all illustrated. The rapidly increasing quantity of grain from the Western Provinces which was now carried through the mountains for shipment from Vancouver was noted, practically 14½ million bushels having been routed that way in 1922. A further series of slides showed the transportation of timber from the forest to the sawmill or paper-mill; another series dealt with the fishing industry and so on. A vote of thanks to the author of the paper was moved by Sir Henry Fowler, who commented on the work involved in establishing so vast a railway system and the rapidity with which it had been accomplished. For ten years he believed that the Canadian Northern Railways had increased their track at an average rate of one mile per day. Professor Hudson Beare inquired as to the financial results of Government operation of the Canadian National Railways, as compared with the operating results of the Canadian Pacific Railway Company. He thought that what the railways needed most was a denser population in the vast areas traversed, and hoped that British immigration would do as much as possible to provide this population. Mr. Cleworth referred to the difference between Canadian and European conditions, in that in Canada the population came after the railway was established, while in Europe the reverse was the case. He reminded the meeting that the completion of the Canadian Pacific Railway from coast to coast was one of the conditions laid down by British Columbia for its consent to enter into the Federal System of Canada. When that railway was surveyed, it was the intention of the engineers to cross the Rockies through the Yellowhead Pass, but this route was abandoned in favour of the Kicking Horse Pass considerably further south, although the more northerly pass involved much more favourable grades. In those days it was considered that the Yellowhead Pass was too far north for the route to serve the wheat-growing country, but the wheat belt was extending further and further north, and the rails had now been laid through the Yellowhead for some years. In reply to a question by the same speaker as to the possibility of railway electrification in Canada, Mr. Henry said that the matter had been fully investigated, but at present the density of the traffic was too low to make such a course advisable, notwithstanding the large amount of waterpower available. Referring to Professor Hudson Beare's remarks, Mr. Henry said that the annual report of the Canadian National Railways gave full information as to the financial results obtained.

Engineering Problems and Traffic on the Great Lakes.

The final paper of Thursday morning session was one by Lieut.-Colonel H. S. Lamb, D.S.O., entitled "Engineering Problems and Traffic on the Great Lakes." Like the preceding paper it was very largely a lantern lecture, and it gave a very good idea of the immense importance of the great international system of waterways extending so far across the American Continent. There are two great obstructions to navigation between Port Arthur at the end of Lake Superior and the St. Lawrence, namely, the Sault Ste. Marie, or the "Soo" between Lake Superior and Lake Huron, and of course Niagara Falls between Lake Erie and Lake Ontario. The Soo Canal and docks to avoid the former and the Welland Canal to short-circuit the latter were discussed in considerable detail, numerous drawings of the actual engineering constructions, such as harbours, breakwaters, locks, &c., being thrown on the screen. The magnitude of the traffic on the Great Lakes was illustrated by one very striking fact, namely, that the tonnage passing through the Soo Canal was more than the aggregate tonnage passing through the Suez Canal, the Manchester Ship Canal and the Panama Canal taken together. There was unfortunately no time for discussion on this paper, but we hope to give an abstract of it in due course.

Toronto Harbour and Filtration Plant.

Instead of listening to any papers during the afternoon of August 7, the members of the Engineering Section, augmented by many from other sections who preferred the beauty of Lake Ontario to the internal architecture of the university buildings, took advantage of facilities provided by the Royal Canadian Yacht Club to see the harbour and island. Fast steam and motor launches took the party several miles along the lake front and round the island, after which they were entertained to tea by General and Mrs. Mitchell at the Yacht Club on the island. Toronto harbour has been designed to accommodate the large vessels which will come to the city when the Welland Ship Canal and the St. Lawrence improvements permit ocean traffic to reach the Great Lakes. The harbour-work now in progress involves the construction of some 15 miles of piers, wharves and quays alongside which there will be a navigable depth of 24 ft. with provision for an ultimate depth of 30 ft. When complete the harbour will accommodate over 100 vessels between 5,000 and 10,000 tons capacity, and will be equipped to complete their unloading within 24 hours from the time of docking. The dredging operations are carried out in connection with land reclamation schemes. Over 500 acres of land have already been fully reclaimed and are occupied by industrial buildings and plants valued at about 2,000,000*l*. The proximity of this area to the business centre of the city, only 1¼ miles distant, together with the excellent facilities for rail and water carriage and the cheap hydro-electric power available all render it an almost ideal manufacturing site. It may be mentioned as evidence of the development of Toronto as a port that the shipping entering and leaving the harbour increased from 1,954 vessels of 1,267,732 net tonnage in 1918 to 4,610 vessels of 3,012,514 net tonnage in 1923.

The island, which has a summer population of about 12,000 residents, has great natural beauties, but from the engineering point of view it is particularly interesting as the site of the filtration plant for the City of Toronto. The water from Lake Ontario is pumped to the plant through two intakes terminating 3,200 ft. from the outer shore of the island. The daily water consumption of the city is about 65 million gallons, of which about 25 million gallons are dealt with by the old slow sand covered filters which occupy several acres, and the remainder by the newer shifting sand filters. The installation of these filters, which is the largest of the type in the world, comprises ten units each 50 ft. in diameter and rated at six

million gallons per day. The normal rate of filtration is 150 million gallons per day per acre of sand, which may be compared with the rate of five million gallons per acre at which the older slow sand filters are operated. The invention of the shifting sand filters was due to Mr. W. Gore, who kindly acted as guide to the party of inspection and explained the principle. To put it briefly it may be said that the working surface of each filter consists of a number of conical heaps of sand which are continually renewed by the addition of clean sand at the apex of each cone. The sand travels down each cone and is withdrawn at the bottom by pipes which lead it to a chamber where it is washed with filtered water and returned to the apex of the cone, this cycle of events taking place continuously and automatically. The sand forming the stationary core of each cone needs washing only at comparatively lengthy intervals, and this is effected by the reversal of the water flow in the way usual with rapid filters.

The Toronto installation is a very imposing one, and the principle gives excellent bacterial reduction, a matter which is of great importance at Toronto where contamination of the crude water has always to be reckoned with. The sewer outfall is in the lake about 5 miles distant from the intakes, and although this distance would seem sufficiently great to avoid polluted water reaching the intake it is an undoubted fact that contamination does occur when there is a persistent wind in the right direction. The result of such conditions is shown by the presence of the colon bacillus in large numbers, but an earlier warning is the increase in the free ammonia content of the water. This can be detected practically immediately it occurs, whereas the bacteriological determination requires at least 24 hours. To show how bad conditions may be from contamination by sewage from the outfall or faecal matter from passing ships, it may be said that colon bacillus has been found present in the raw water in numbers up to 1,000,000 per cub. centimetre. The harmlessness of the filtered supply is ensured by continuous chlorination which effectively destroys any dangerous bacilli which might escape the filters. The latter normally work without alum or other coagulant being added to the water, but whenever there is reason to fear pollution of the raw water alum is used as an additional safeguard. A sensitive and ingenious device is provided for supplying alum. The crystals are dissolved to form a strong solution in which is a float attached to a lever arrangement controlling the admission of the solution to the water. Any variation in density of the solution will cause the float to rise or fall, on the principle of a hydrometer, and thus to maintain constant the quantity of alum admitted. By moving a counter-weight along a graduated scale on the lever, the attendant can regulate the quantity admitted. The water after filtration and chlorination flows by gravity to the city, a distance of two miles, through tunnels under the arm of the lake, and is then passed through high-lift pumps.

The Waterpowers of Canada.

The morning session of Friday, August 8, was devoted to the consideration of three papers, all dealing with particular aspects of the water-power resources of the Dominion. The first of these, entitled "Water Powers of Canada: An Outline of their Extent, Utilisation and Administration," by Mr. J. B. Challies, the Director of the Dominion Waterpower and Reclamation Service, was read, in the absence of the author, by Mr. Norman Mare. By the aid of lantern slides the audience were given some idea of the enormous waterpower developments of the Dominion, every plant of any importance from the Pacific to the Atlantic Coast being illustrated in turn, the long sequence of imposing works shown on the screen doing more to impress the mind with the extent to which hydro-electric power is used than any number of figures. The statistical substance of Mr. Challies' paper we hope to reproduce in a later issue. The modern waterpower industry began in the Dominion about 1895, and has grown with extreme rapidity. During the last 10 years while the population has increased by 22 per cent., the development of waterpower has increased by 100 per cent., and its use for industrial purposes by 245 per cent. The total waterpower throughout the Dominion is estimated at over 18 million horse-power, of which 3,227,414 h.p. are now developed and another 750,000 h.p. will shortly be brought into service. The capital invested in hydro-electric development, transmission and distribution has grown from 121,000,000 dols. in 1910, to 688,000,000 dols. in 1923.

The second paper of the day was entitled, "The Hydro-Electric Power Commission of Ontario," by Mr. F. A. Gaby, the chief engineer of the Ontario Hydro-Electric Commission. In Mr. Gaby's absence the paper was read by Mr. A. B. White. The paper, as delivered, went far beyond the description of the Queenston-Chippawa development, which we commenced reprinting in our last issue and conclude elsewhere in this issue, and dealt in some detail with the origin of the Hydro-Electric Power Commission and its activities. The "Hydro" as it is familiarly called is an organisation based upon the co-operation of a large number of municipalities in Ontario for the purpose of developing the water powers of the Province to the best advantage. It is absolutely non-political and has very far reaching powers, which under the direction of Sir Adam Beck, who has been chairman since the inception of the scheme nearly 20 years ago, have been exercised to the immense advantage of the Province. Briefly it may be said that the "Hydro" controls the whole of the waterpower of Ontario, and develops and distributes it to the greatest advantage of the population. Its sales of power amount to millions of dollars per annum, and all profits are returned to the co-operating minicipalities. The operations of the "Hydro" have been enormously successful, and power is extremely cheap and widespread throughout the Province. If it were possible to organise the electricity supply of Great Britain by a powerful authority with the same technical and administrative ability as displayed by the Hydro-Electric Commission of Ontario in the management of their far larger and more widespread business, the results would be surprising. We hope to give an account of the way in which the Hydro-Electric Commission fulfils its duties at some future time, as its methods might be applied with advantage beyond the confines of the Province of Ontario.

The third paper, by Mr. R. S. Lea, was entitled "The Development of the St. Lawrence River for Power and Navigation." This, like its predecessors, was illustrated by lantern slides, and was the more interesting because many of the audience had travelled up the St. Lawrence from Montreal under the guidance of Mr. Lea. Mr. Lea's paper dealt with two alternative proposals for rendering the St. Lawrence navigable for large vessels for the whole distance from Montreal to Lake Ontario, and at the same time utilising the whole fall of the river in that distance for the development of power. The author dealt fully in his paper with the principal features of the respective schemes, and as we reproduce his paper in our last and the present issue, there is no need to summarise it here. The great national importance of both hydro-electric development and internal navigation in Eastern Canada at the present time, makes it as certain as anything can be that sooner or later it will be made possible for ships to sail direct from Liverpool to the towns of the Great Lakes, and the necessary works will render available millions of horse-power.

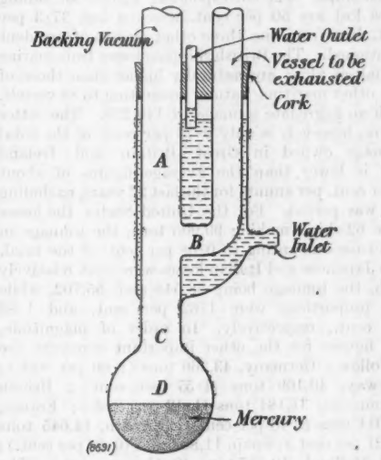
There was no time for any discussion on any of the three papers which we have mentioned. A vote of thanks to the authors was proposed by Professor F. C. Lea, who expressed his admiration for the boldness in conception and the courage in execution shown by the engineers of Canada in the development of the natural resources of the country. Mr. J. S. Wilson, who seconded the motion, said that when inspecting, under the guidance of Mr. R. S. Lea, the rapids of the St. Lawrence, which it was proposed to harness, he had been reminded of the late Sir John Aird's exclamation to Sir Benjamin Baker when he first visited the site on which he had contracted to build the Assuan dam. At the sight of a mile and a half of roaring torrent, he had cried, "Good Lord, what have I undertaken to do." The very uniform discharge of the St. Lawrence was about equal to the flood discharge of the Nile and about 10 times the minimum flow of the latter river.

(To be continued.)

NOTES.

A New Condensation Pump.

A simple form of the "condensation" pumps now so largely used for producing very high vacua is described in a recent publication* issued by the Research Department, Woolwich. It is stated that metal condensation pumps are costly and inconvenient, and as they are not transparent the first intimation of failure is generally a breakdown of the whole pumping system. The new pump is of glass, and is represented in the diagram herewith. The design is due to Dr. Gilbert West. The top of the tube A is connected to some auxiliary air pump capable of producing a moderately high vacuum. The vessel to be exhausted is connected to the branch B, and as indicated the whole of this upper



portion of the apparatus is water jacketed. The tube A terminates in the bulb D, which serves as the mercury container. On heating D, mercury vapour is generated and passes up the tube A, and condenses on the sides thereof, trickling back finally into the bulb, to be re-evaporated. Owing to the reduction of volume which the mercury undergoes on condensation a rapid current of vapour is always flowing up A when the pump is at work. The mercury, in fact, passes up this tube as vapour and down it as liquid. As the upward current passes the orifice at B it entrains with it molecules of air which diffuse out of B into the main tube A. These are swept up by the ascending current of vapour, and are finally removed from the apparatus by the auxiliary air pump to which, as already stated, the tube A is connected at the top. Much experiment was required to determine the best proportions of the pump. The report states that the pump works very rapidly and produces extremely high vacua.

Losses of Merchant Shipping.

The depression in freights and the consequent need for eliminating the least economical shipping are well exemplified in the wreck statistics recently issued by Lloyd's Register of Shipping for 1923. The gross reduction in the effective mercantile marine of the whole world amounted to 1,716,779 tons for the year, this figure including 968 vessels of 100 gross tons and over which were totally lost, broken up, condemned, &c., in the period under review. The tonnage removed from the Register from these causes is nearly double that for the previous year, the increase being mainly due to the fact that many more vessels than usual have been broken up or dismantled for economic reasons. The tonnage so dealt with in all countries of the world in 1923 amounted to 1,140,207, which is three times the highest figure previously recorded and includes over 200,000 tons of British shipping. The British mercantile marine, it may be remarked, still contains a lower proportion of new tonnage than do those of many of our competitors, so that

*R. D. Report, No. 62, H.M. Stationery Office, Price 1s. 3d. net.

it is probable that the weeding-out process will be continued during the current year. The world's shipping losses in 1923 due to, or consequent upon, marine casualties, amounted to 576,572 tons, comprised in 466 vessels, which is rather heavier than the corresponding figure for the previous year, viz., 516,711 tons. These losses include vessels abandoned at sea, foundered, missing, broken up after damage, in collision, wrecked, &c. Strandings and similar casualties included under the heading "wrecked," constitute the most prolific cause of marine accident and account for 54 per cent. of the losses of steamers and motor ships during 1923, while cases of vessels abandoned at sea, foundered, or reported as missing, which may be taken collectively since the circumstances attending their loss are, doubtless, generally similar, account for 24·4 per cent. of the losses of mechanically-propelled ships. The corresponding figures for sailing ships lost are 50 per cent. wrecked and 37·3 per cent. lost from the three other classes of accident mentioned. The British shipping losses from marine casualties alone are naturally higher than those of any other maritime nation, amounting to 88 vessels, with an aggregate tonnage of 140,335. The latter figure, however, is only 0·73 per cent. of the total tonnage owned in Great Britain and Ireland and is lower than the average figures of about 1 per cent. per annum for the last 22 years, excluding the war period. For the United States, the losses were 62 ships, making 99,905 tons, the tonnage in this case amounting to 0·68 per cent. of the total. The Japanese and Italian losses were both relatively high, the tonnage being 58,548 and 55,702, while the proportions were 1·62 per cent. and 1·82 per cent., respectively. In order of magnitude, the figures for the other important countries are as follow: Germany, 43,266 tons (1·66 per cent.); Norway, 40,109 tons (1·57 per cent.); British Dominions, 31,181 tons (1·12 per cent.); France, 18,011 tons (0·48 per cent.); Sweden, 14,645 tons (1·21 per cent.); Spain 11,862 tons (0·94 per cent.); and Holland, 10,817 tons (0·41 per cent.). The figures, it should be mentioned, relate to vessels of 100 tons and upwards, the tonnages given being gross in all cases.

Trade with Lithuania.

Lithuania, an independent country in its infancy, situated north of Poland and south of two other new independent countries, Esthonia and Latvia, has, unlike the two latter, only a limited sea-coast on the Baltic. A part of Lithuania, however, the territory of Memel on the Baltic, is still untransferred at the present time. This territory and the port of Memel, the natural port of Lithuania on the Baltic, were seized by the Lithuanians last year, and until their rights are fully established the question will continue to have an unsettling influence; the problem has, however, now reached a stage which promises a solution in the near future, according to a report by Mr. H. H. Cassells, H.M. Consul at Kovno. The award of Vilna and of a portion of the surrounding territory to Poland has been greatly resented by the population. Lithuania is essentially an agricultural country, over 80 per cent. of the inhabitants being employed on the land, and if it is to maintain an independent existence economically it must rely chiefly on its exports of timber and agricultural products, and develop along much the same lines as Denmark. From the point of view of British trade and industry the Lithuanian market has limitations; the population is about 2,000,000 and the means of a great portion of the inhabitants are comparatively low. Practically the whole of the metal industry is in the hands of three old-established firms, who employ 563 of the 677 workmen now engaged in the industry, as compared with the pre-war figure of 2,790. These factories, which sold their products before the war as far as Odessa, Kief, Baku and Vladivostock, find it impossible to increase their business with their markets restricted to the Baltic States. Russia, whose buying capacity is very low, has now no common frontier with Lithuania. The commodities most in demand are textiles, foodstuffs, machinery, glass, cement, coal, &c.; of these imports 80·89 per cent. come from Germany, but this includes a certain quantity of goods sent in transit through that country. The percentage of imports from Great Britain is put down as 5·27, but is in reality higher, since many articles received from Germany and Latvia and credited to those two countries are of British origin. It is proposed to raise a loan in the United Kingdom of 1,000,000*l.*, the major portion of which is intended to cover the material necessary for the construction of two new broad-gauge lines, also to provide for the construction and equipment of central railway workshops. The new currency unit in Lithuania, a paper currency, is the litas, and in 1923 the rate of exchange varied between 47 and 43 litas to the *l.* The report from which we take these notes can be obtained at the price of 1*s.* 0½*d.* from H.M. Stationery Offices.

THE LATE ADMIRAL SIR CYPRIAN BRIDGE.

The death of Admiral Sir Cyprian Arthur George Bridge, G.C.B., which we regret to state occurred on Saturday last at his Kingston residence in his 85th year, brings to an end a long and useful career, which has been devoted entirely to the naval service of the country. Sir Cyprian, in recent years, has done much to stimulate naval thought and to enlighten public opinion upon matters connected with the policy of naval defence, having been a frequent contributor to the Press when naval questions were under discussion. He also took part on many occasions in discussions on strategy and tactics at the meetings of the Institution of Naval Architects, from which his views will probably be familiar to our readers. His paper entitled "Fifty Years' Architectural Expression of Tactical Ideas," read at the Jubilee meetings of that Institution in 1911, was also reprinted in our issue of July 7, 1911, on page 37.

The subject of our memoir, who was born in Newfoundland on March 13, 1839, entered the navy as a cadet in January, 1853, when less than 14 years of age, serving in the White Sea in the following year in the war with Russia, and afterwards in the Bay of Bengal during the Indian Mutiny. He became a lieutenant in 1859 and a commander 10 years later, attaining the rank of captain in 1877. Periods of service at sea interspersed with committee work on shore, mainly in connection with ordnance, armour and intelligence matters, occupied him at about this time, and some years later, viz., in 1889, he was appointed Director of Naval Intelligence at the Admiralty. While occupying this position, which he held until 1894, he was promoted to flag rank, and later to the rank of vice-admiral. His next appointment was as Commander-in-Chief on the Australian Station, and in 1901 he took over the command of the China Squadron, being appointed Admiral in 1903.

This was his last command, but his retirement in 1904, after over 51 years of service, by no means severed his connection with naval work, since, in the same year, he presided over the Commission entrusted with the investigation of the circumstances in which the Russian Fleet, on its way to the Far East during the Russo-Japanese war, fired on some British fishing vessels on the Dogger Bank. His more extensive leisure, however, allowed him time for literary work and for the public discussion of naval matters. Among other publications he was the author of "The Art of Naval Warfare," and "Sea Power and Other Studies," while a volume of reminiscences, published as recently as 1918, gives an interesting account of his early experiences in the service and throws much light on conditions in the Navy in the middle of last century. He was a frequent contributor to the journal of the Society for Nautical Research, in the work of which he took a very active interest, having been a member of the original council as well as of that of the Navy Records Society.

Technically, his most important work for the Navy was in connection with the various committees on heavy guns, explosives, armour plates and projectiles on which he served between 1878 and 1881, but his life's work, first as an efficient and energetic officer and afterwards as an accurate and judicious writer, must have contributed materially to its development.

Superheater Steam-Roller.—To meet the increasing need for road repairs, the Schweizerische Lokomotiv und Maschinenfabrik, Winterthur, have constructed a superheater steam-roller which differs in several respects from the usual types. One of the principal objects has been to take the strain off the boiler. For this purpose the boiler is made to lie high in the framing, to which it is fixed in front, the back end being free to slide. The fire-box is large, and a Schmidt superheater is fitted. The twin engine can develop from 13 h.p. to 20 h.p. To prevent any possibility of the roller sinking in soft ground, a strong horizontal base plate has been fixed to the frame, behind the two driving wheels. The width of the roller is 1·85 m. (73 in.). According to the *Schweizerische Bauzeitung*, these rollers can work at higher speed than the older types and have proved economical.

THE LATE MR. GILBERT GILKES.

We regret to have to announce that the death of Mr. Gilbert Gilkes occurred at his residence at Kendal on the 13th inst., on his seventy-ninth birthday, after a long illness. Mr. Gilbert Gilkes was the son of Mr. Bedford Gilkes, of Nailsworth, Gloucestershire. He received his early education at the Friends School, Kendal, on leaving which, in 1861, he served as an articled pupil to Messrs. Gilkes, Wilson and Co., of Middlesbrough, for 3¼ years, remaining in this firm's service for seven years subsequently. In this connection he was occupied with bridge, engine and blast furnace work. At the age of 21 he was engineer-in-charge of the large bridge on the River Dee at Kirkcudbright. He rose to be general manager of Messrs. Gilkes, Wilson and Co., afterwards Messrs. Hopkins, Gilkes and Co., before leaving. After some time spent in Birmingham, in 1881 he purchased the business of Messrs. Williamson Brothers, of Kendal, hydraulic engineers, and thence forward devoted himself to hydraulic work and the design and application of hydraulic turbines, water wheels, &c. His experience of bridge work continued to be of service to him, and he was engineer for a bridge at Kendal in 1887, though most of his work by that time was concerned with the hydraulic-power branch of engineering.

In the early days of modern water-power developments Mr. Gilkes was responsible for carrying out a number of important private installations and, in conjunction with Mr. D. J. Pennington, installed plants at Balmoral and Chatsworth. At the time that he took over Messrs. Williamson's business practically the only turbine manufactured was the Vortex turbine of Professor James Thomson. The business of the firm was gradually developed until their work included mixed-flow turbines of different types, Pelton wheels and the Turgo impulse type for high falls, invented by Major Crewdson. A description of this type of turbine and its distinctive features as compared with the Pelton wheel will be found recorded in Engineering (vol. cxvi, page 279), where we give an account of the installation by Messrs. Gilbert Gilkes and Co., Limited, of a plant at Cynwyd, North Wales.

Mr. Gilkes retained the chairmanship of the firm up till 1920. He was pre-eminently interested in the civil engineering side of water-power projects, and latterly was wont to leave mechanical design to others. It may be mentioned that in an international competition in connection with the first project for utilising the power of Niagara, a scheme planned by Messrs. Gilkes and Pennington was awarded second prize.

Very active in public work, Mr. Gilkes was a Justice of the Peace for Westmorland and for Kendal. He was an original member of the Westmorland County Council, and an Alderman from 1895 till 1921. For 21 years he was Chairman of the County Education Committee, and from 1895 onwards was Chairman of the Kendal Education Committee. For three years in succession he was Mayor of Kendal.

He was an original member of the Iron and Steel Institute, and for some time was a member of the Council of the Cleveland Institution of Engineers. He became an associate member of the Institution of Civil Engineers in 1886 and was transferred to full membership in 1892. He was succeeded in 1920 in the chairmanship of the firm by his nephew, Mr. N. F. Wilson.

French Submarine Construction.—On July 19, the new French Minister of Marine, Monsieur Dumesnil, was present at the launching of the submarine Requin, at Cherbourg. The Requin is one of the first-class submarines provided for under the naval programme of April, 1922. She will be finished in April of next year, and the five other submarines of the same class will follow at short intervals. Her characteristics are: displacement, 1,139 tons; horse power, 1,450; speed, 16 knots on the surface, and 10 knots submerged; length, 256 ft. Her radius of action at economical speed is about 8,000 miles, and she can resist the pressure corresponding to a depth of 55 fathoms.

The Automobile Tax.—We are informed that the Third Interim Report of the Departmental Committee on the Taxation and Regulation of Road Vehicles, dealing with the existing system of motor-car taxation is now available, and copies (price 2*s.* 6*d.*) may be purchased direct from H.M. Stationery Office or through any bookseller. The main report contains the following general conclusion:—"It is in these circumstances that we have again reluctantly come to the conclusion that no method of administering a motor-spirit duty can be contrived which would not inflict grave inconvenience and additional expense upon considerable numbers of consumers of motor spirit—and of some kerosenes—used for purposes other than the propulsion of road vehicles or which could be relied upon to yield a certain revenue at a reasonable cost." The report is divided into two parts, Part I containing an historical survey, dating back to the eighteenth century, of the various systems which have obtained in this country in connection with the taxation of vehicles and to the expenditure on roads. Part II deals with the disadvantages of the present system of motor-car taxation and contains suggested alternative methods and modifications.

THE CABLE-HANDLING MACHINERY OF THE "EDOUARD SUENSON."

CONSTRUCTED BY MESSRS. JOHNSON AND PHILLIPS, LIMITED, ENGINEERS, CHARLTON, LONDON.

Fig. 16.

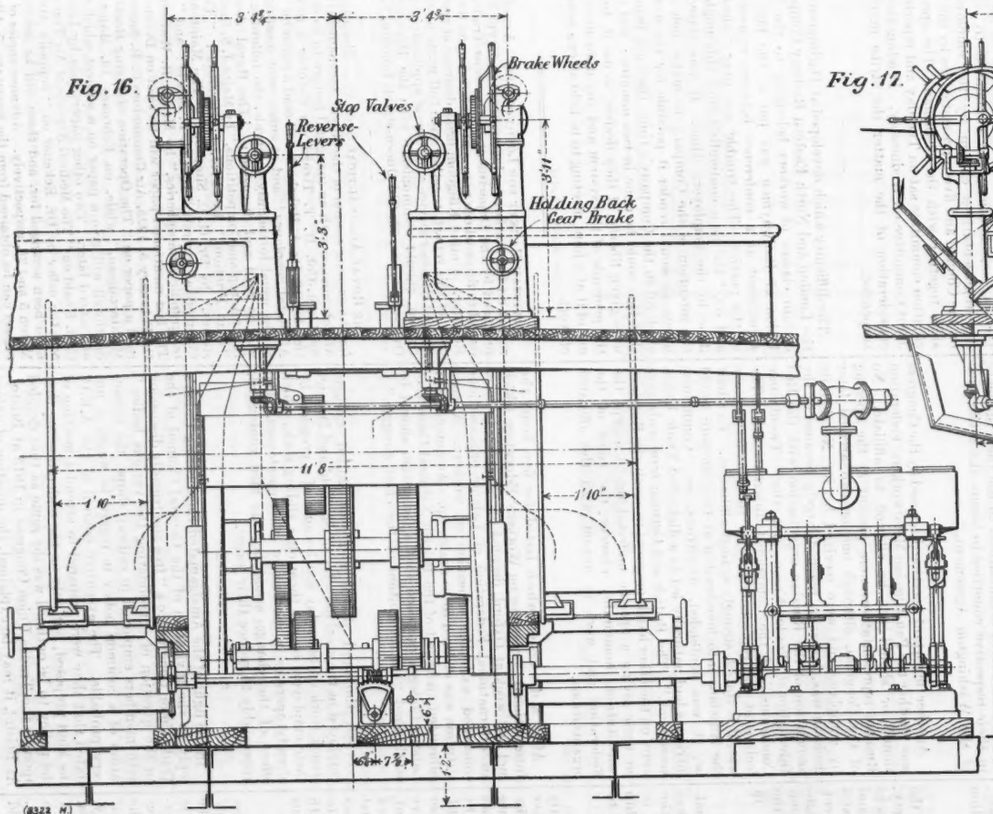
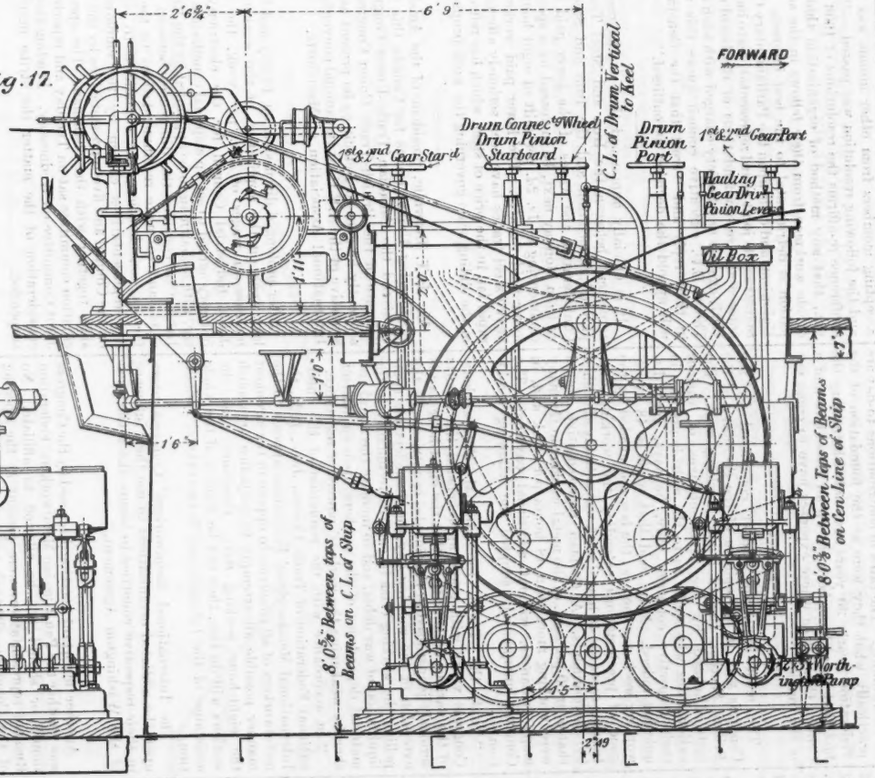


Fig. 17.



THE CABLE-LAYING AND REPAIRING STEAMER "EDOUARD SUENSON."

(*Concluded from page* 197.)

THE electric installation consists of two steam-driven generator sets giving a supply at 110 volts. The larger set is of 20 kw. capacity, and was supplied by the Titan Company, of Copenhagen, and the smaller one, which is of half that capacity, combines an engine made by the builders and a dynamo supplied by Messrs. Th. B. Thrige, of Odense, Denmark. A wireless installation of 1·5 kw. capacity, working on the Telefunken system, was fitted by the Dansk Radio.

The auxiliaries in the engine room consist of a circulating pump for the condenser, an air pump of the Edwards type operated from the main engine, two Weir feed pumps, a simplex ballast pump, a service pump of the Duplex-Selandia type, an electrically-driven centrifugal sanitary pump, and a steam-driven fan engine for the supply of artificial draught. Pipe arrangements are fitted to permit the use of the general service pump, the ballast pump and a donkey bilge pump to deal with the water for the ballast and cable tanks. There is an evaporator of 10-tons capacity and a distilling apparatus of 4-tons capacity, with the requisite filter, supplied by Messrs. G. and J. Weir, Limited, of Glasgow.

On the main deck, above the forward part of the first cable tank, the cable machinery is erected. This equipment is a double combined picking-up and paying-out machine made by Messrs. Johnson and Phillips, Limited, of Charlton, London. Illustrations of this plant are given in Figs. 14 and 15 on page 262, and in Figs. 16 and 17 on this page. The cable machine consists of two separate devices, the one for picking-up and the other for paying-out, and they are driven by two separate engines, but arrangement is made that one or both engines may operate either or both of the gears. In addition to this facility of combining the power units, the design is such that both brakes may be made to act upon either drum. Each of the high pressure two-cylinder engines develops 110 brake horse-power at 300 r.p.m., steam supply being obtained at 11·2 kilogrammes per square centimetre (160 lb. per square inch). Fig. 14 shows the arrangement of the complete cable-handling plant assembled in the workshop. The engines are erected on the main deck so that they have their crankshafts at right angles to the longitudinal axis of the vessel. Fig. 15 gives a view of the same plant as it would appear from a position forward on the main deck.

The drive from each engine is carried by shafting and pinions to the main gearing of the equipment. Each of the two machines is arranged for two speeds. The picking-up machine will lift 25 tons at a speed of 1 knot or 10 tons at a speed of 2½ knots, with both engines coupled for the work. The paying-out machine can haul 10 tons when the speed of operation is 2½ knots or 6½ tons at 4 knots, again with both engines in use. The drums, each of which is provided with counters to register, in plain figures, the work done in picking-up or paying-out, run loose on fixed shafts, but are fitted with screw brakes. These are each worked by two handwheels, one operating the brake screw, through screwgearing, giving a quick action, while the other acts through a spur-reduction gear in addition, and gives a slower but more powerful action. By the use of this arrangement quick operation is secured as well as fine adjustment for paying-out and large power for holding in position. The starting and reversing gears, the handwheels for the main and holding-back gear brakes, and all the actuating gear for altering the speed by changing the gear wheels in use, are placed on the awning deck within easy reach of one another, so that the control is centralised.

For each machine there is provided a separate hauling-off and holding-back gear placed upon the awning deck in front of the cable machine hatches, and driven from the drums by means of endless chains. Each gear is provided with a V-sheave and jockey pulley. Two dynamometers, to register the cable strains, are provided between the bow sheaves and the cable machinery. These give readings between 8 cwt. and 15 tons in normal work, but values up to 25 tons can be recorded by them. Deck leads near the cable hatches facilitate the handling of the cable between the tanks and the cable machinery. On the awning deck, and just in front of each of the main

and aft cable tanks, there are horizontal steam winches of 3 tons capacity, made at Svenborg. The shafts of these winches are extended and provided with warping drums for docking purposes. These winches also drive, by means of endless chains, V-sheaves provided in association with jockey pulleys and are equipped with counters registering to one-thousandth of a nautical mile. This arrangement is introduced to facilitate the conveyance of the cable to and from the tanks.

The steam steering engine in the engine-room casing, and the emergency hand-steering gear on the rudder shaft, are of ordinary types and were supplied by Messrs. Stuhr's shipyard at Aalborg. There are mechanical telegraphs on the awning deck and on the bridge, a mechanical rudder indicator at the front of the bridge, an electric revolution recorder in the steering house, and the customary speaking tubes and bell indicators, so that effective control and accurate knowledge of the working is obtainable throughout the whole period of activity. A range finder made by Messrs. Barr and Stroud of Glasgow, facilitates the taking of accurate observations. The anchors were constructed so that sharp projections, which might injure the cable, have been avoided.

LABOUR NOTES.

At its meeting in London on August 12, the joint committee formed of one member of each of the engineering trade unions interested in the national application for an advance in wages of 20*s.* per week, passed the following resolution:—"That a sub-committee of six, including the chairman and secretary, be appointed to confer with the Research Department of the Trade Union Congress in regard to the statements made by the chairman of the Engineering and Allied Employers' National Federation at the several conferences that have been held between the employers and the unions with reference to the unions' application for a national advance in wages of 20*s.* per week and report to a further meeting of the committee." The chairman is Mr. J. T. Brownlie, president of the Amalgamated Engineering Union, and the secretary, Mr. Frank Smith, general secretary of the Federation of Engineering and Shipbuilding Trade Unions.

In the August issue of the Monthly Report of the Boilermakers' and Iron and Steel Shipbuilders' Society, it is stated that members employed at Bristol Docks have secured an advance in wages of 6*s.* per week, and that an agreement has been concluded with Bristol Channel employers for an advance of 5*s.* per week in two instalments. The number of members "signing the book" at the end of July was 16,812 as compared with 20,201 a month earlier. In June the organisation's expenditure was 63,063*l.* 3*s.* 4*d.*; in July, it was 58,633*l.* 4*s.* 6*d.*

According to the latest official report of the Amalgamated Engineering Union unemployed members were fewer by 1,081 in July than in June. At the beginning of August the total number was 18,812, or 8·19 per cent. of the membership. The membership of the society declined during July from 255,669 to 253,355.

The first of the three financial proposals recently submitted to a ballot of the members by the executive council of the Boilermakers' and Iron and Steel Shipbuilders' Society has been carried. In accordance with this decision the contributions of first-class members will, as from September 1, be increased by 6*d.* per week, those of second-class members by 4*d.* per week, and those of third-class members by 2*d.* per week. In announcing the change the executive council say that members "who are working and, therefore, will be called upon to pay the increased contributions, will have the satisfaction of feeling that in making this sacrifice they are assisting their less fortunate out-of-work members, who will again be entitled to Home Donation, if in compliance with rule, from the same date as the increased contributions take effect."

On the recommendation of the Central Committee, the Tenth Congress of the International Metalworkers' Federation decided that the contributions for the current year should be at the rate of fr. 18·75 Swiss currency per 1,000 members, that affiliated organisations should be requested to make a special contribution of an aditional 50 per cent. to the funds of the Federation, and that from January 1, 1925, the regular contributions should be raised to fr. 30 Swiss currency, or for the British Section to 25*s.* per 1,000 members. The feeling of the delegates was, it is stated, that if the Federation is to become an effective institution on behalf of the metalworkers throughout the world, it is imperative that greater financial assistance should be forthcoming. The rates of contributions to-day are practically what they were at the foundation of the Federation nearly 30 years ago, notwithstanding the fact that there have been set up an Executive and a Central Committee whose expenses have to come out of the funds.

The most important matter considered by the Congress was, in the opinion of the Secretary of the British Section, the 48 hours' working week. The facts disclosed by the representatives of various nationalities who spoke as to the eight-hours day in their respective countries were, he says, very disquieting indeed. Many said that while a 48 hours' working week was the law, the law was evaded by the issue of proclamations extending the working day. In some cases the 48 hours' week was actually abolished by Governments. A German representative stated that over 50 per cent. of the metal-workers in Germany were working more than 48 hours per week and, in many instances, without additional payment. The Congress unanimously adopted the following resolution:—

"That the Tenth International Metalworkers' Congress views with grave apprehension the reports of the various organisations that the eight-hour day is seriously jeopardised in Continental countries. By the extension of the working day the financiers are compelling the working class to contribute unfairly to the liquidation of war debts, and to increase the moral and material dependence of the workers upon capitalism, thereby weakening the workers' powers of resistance.

"In accordance with the resolution of the International Federation of Trade Unions, June, 1924, the International Metalworkers' Federation appeals to the metalworkers of all countries to oppose in the strongest manner possible all attempts to prejudice or abolish the eight-hour working day. Conscious that the workers will do this, they can be assured of the whole assistance of the International Metalworkers' Federation.

"The International Metalworkers' Congress urges upon the affiliated organisations to use their influence in their respective countries to secure the ratification of the Washington Agreement."

Another important question discussed by the Congress was whether the Pan-Russian Metalworkers' Federation should or should not be allowed to affiliate. No Russian representatives were present at the opening of the Congress, although one or two arrived later by aeroplane and were received by it. No definite decision was, however, reached largely because of the association of the Russian organisation with the Red International Trade Union and the "Twenty-one Conditions" of the Communist International. The feeling of the representatives of the smaller nations was, it is stated, strongly against affiliation. To admit the Russians into membership at this juncture would be, it was contended, disastrous, as "Communist intrigues had naturally led to a disrupted Trade Union movement." The British and German representatives were, on the other hand, prepared to admit the Russians on their giving a specific undertaking to accept the constitution, honourably observe the rules of the Federation and work in unison with the affiliated organisations.

After a discussion which lasted for five hours the International Conference on Workers' Education which met last week at Oxford, decided on Saturday to form an International Federation of Labour organisations concerned with the education of workers. A constitution was ordered to be drawn up. An amendment submitted on behalf of the British National Council of Labour Colleges proposed that a federation should be established "on recognition of the class struggle."

Seven thousand skilled and semi-skilled workers employed in the steel industry of Sheffield and District struck work on Saturday last because of a proposal by their employers to put them on a sliding scale, which already operates in the case of other employees. The effect of the change would be, the men contended, appreciably to reduce their wages.

In the light of the Amalgamated Engineering Union's reply to the invitation of the General Council of the Trade Union Congress to a "free and friendly discussion on the question of consolidating the various bodies" with members employed in railway shops, the formulation of a common policy in regard to wages is not very probable. The executive council of the A.E.U. stated that they were prepared to attend a meeting of the kind proposed, but only on the understanding that the policy to be outlined was the same as that decided upon by the Trades Union Congress in 1915 at Bristol. At Bristol, it may be explained, the question of unions accepting members from other unions was discussed, and the following resolution was passed:—"That this conference re-affirms the resolutions of 1906 and 1907, viz., that any method of organisation that seeks to divide workmen from their fellows in the same occupation is detrimental to the best interests of Trade Unionism, and calls upon the Parliamentary Committee to instruct its joint board representatives to immediately enforce the recommendations of the board of June 5, 1907, against any Society charged with such conduct." The A.E.U. executive council quote this resolution in their reply and "trust that the General Council will uphold the decision as outlined."

It is officially announced that as the result of an agreement between the Iron and Steel Trades Employers' Association and the Iron and Steel Trades Confederation the wages of the lower paid men will, as from Monday next, be increased by a special bonus commencing at 1*s.* 2*d.* per shift of eight hours for the lower paid workers. The lower paid workers in the heavy steel trades have been seriously affected by the rapid fall in the price of steel, which has reflected itself in the sliding scale governing the work-people's wages.

M. J. T. Brownlie, president of the Amalgamated Engineering Union, leaves for Canada this week-end to attend the Canadian Trade Union Congress as a delegate of the British Trade Union Congress. Subsequently he goes to Detroit to be present as a representative of the A.E.U. at the annual convention of the International Association of Machinists.

After prolonged discussion on Friday and Saturday last week on the application of the workers for an increase in wages of 10*s.* per week, the National Joint Industrial Council for the electricity supply industry agreed to set up a special conciliation committee, with a chairman to be appointed by the Ministry of Labour to consider the differences between the two sides, and to make recommendations to the Council for its consideration, the committee to consist of five representatives chosen by the employers' side on the Council and five representatives by the workers' side, together with the chairman. The special conciliation committee sat on Tuesday and reported to the Joint Committee on Wednesday. Pending this further consideration of the matter the strike notices were suspended.

The difficulty which developed at Darlington between the London and North Eastern Railway Company and certain classes of workers belonging to the National Union of Railwaymen was put in the fair way to adjustment at a conference between representatives of the parties. The trouble was over "clocking off and on," the men contending that this ought to be done in the employers' time. It was stated to be the intention of the Company to make such arrangements as would render it possible for the workers to clock off in the Company's time, the view being taken that this could be done in two minutes; and the men were given liberty, if they desired to use it, to discuss the principle of the system and any difficulties arising out of it at a joint meeting to be held after a resumption of work.

Egyptian Market for Locomotives.—A confidential report on the market for locomotives in Egypt has been prepared by the Department of Overseas Trade, and is issued to firms whose names are entered upon its Special Register. United Kingdom firms desirous of receiving a copy of this report, together with full particulars of the Special Register service and form of application for registration, should communicate with the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1.

The Royal Aeronautical Society.—The programme for the ensuing session of the Royal Aeronautical Society will commence with an inaugural lecture to be delivered by Lieut.-Col. H. T. Tizard, on October 2 next. On October 16, Dr. A. Rohrbach will read a paper on "Large All-Metal Seaplanes" and at subsequent meetings, held at the usual fortnightly intervals, the following papers will be read and discussed: "The Royal Aero Club Light Aeroplane Competitions," by Major J. S. Buchanan; "Skin Friction," by Prof. L. Bairstow; "Thunderstorms," by Dr. G. C. Simpson; "The Maintenance of Commercial Aircraft," by Col. F. Searle; and "Radio-telegraphic Atmospherics," by Mr. A. R. Watson Watt. The last-mentioned paper will be read on December 18. On February 5, 1925, Air Commodore C. R. Samson will read a paper on "The Operation of Flying Boats in the Mediterranean," while, on February 19, Major R. V. Southwell will give a paper on a subject which will be announced later. Two other papers, one by Lieut.-Col. C. B. Heald on "The Medical Aspects of Air Transport" and the other by Dr. Eckener on "Zeppelin Airships," have been arranged for, and these will be delivered on March 5 and 26, respectively. Advance copies of all the papers can be obtained from the Secretary, 7, Albemarle street, W.1., at the price of 6*d.* each, or 5*s.* for the series.

THE DEVELOPMENT OF THE ST. LAWRENCE RIVER FOR POWER AND NAVIGATION.*

By R. S. LEA, M.Inst.C.E.

(*Concluded from Page* 241.)

Methods of Development.—It has already been indicated that in the development of the "power reach" of the St. Lawrence, natural conditions have divided it into three stretches, each of which must be dealt with separately. The two lower ones, which are short and made up almost entirely of rapids, have been shown by the investigations of the engineers of the Government Deep Waterways Project, to be particularly adapted to improvement for navigation by the method of side canals, which work can be carried out quite independently of the development of power. The latter is an important feature, in view of the fact that both stretches are wholly in Canadian territory.

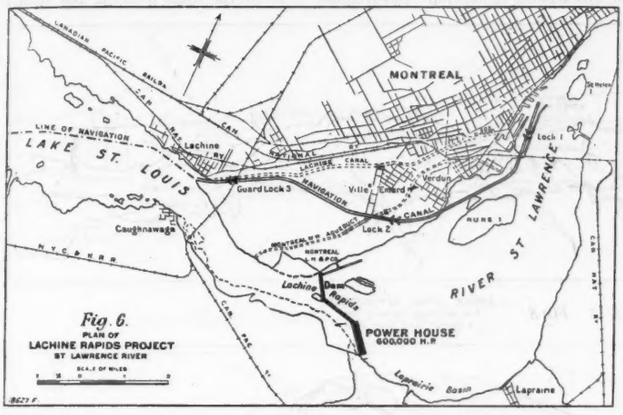


Fig. 6.
PLAN OF
LACHINE RAPIDS PROJECT
ST LAWRENCE RIVER

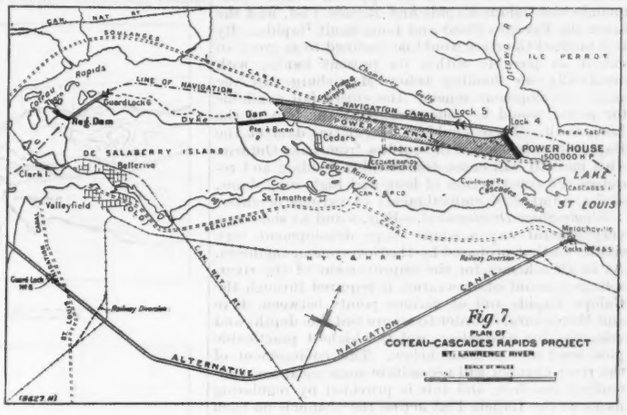
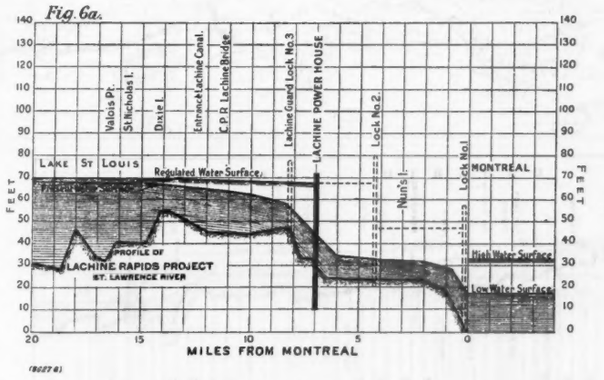
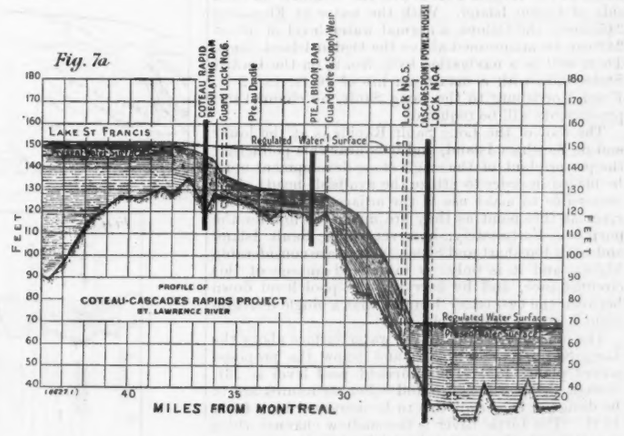


Fig. 7.
PLAN OF
COTEAU-CASCADES RAPIDS PROJECT
ST. LAWRENCE RIVER





Besides this the development of these powers would naturally and advantageously follow those of the rapids above. The Deep Waterways scheme contemplates an ultimate depth of 30 ft., but in making the estimates provision has been made for an initial minimum depth of 25 ft. in the canal reaches and river channels, with the locks and other permanent structures constructed for the full draft of 30 ft. For purposes of a very general description, it may however, be considered as a 30-foot project.

Montreal Harbour to Lake St. Louis.—For the lowest stretch, from Montreal Harbour to Lake St. Louis, several alternative plans for a canal about 9 miles in length have been proposed, differing principally in the route chosen. One of these, which may be the one finally adopted, is shown in Figs. 6 and 6a. It begins with an entrance lock, No. 1, in Montreal Harbour, and this numbering is continued throughout the whole stretch of the river up to lock No. 9, a little above Morrisburg, which completes the total lift. Lock No. 1, with a lift of from 22 to 32 ft. according to the river stage, leads to a section constructed in the river, and carried between an outside retaining wall and embankment and a levee or flood protection dyke which is already in existence along the river shore. The space thus enclosed may be utilized as a high level shipping basin, forming part of a scheme for greatly increasing the terminal and dock facilities of the harbour. Lock No. 2 is located at the further end of this section, and has a lift of 16 ft. The next section turns northward towards the present Lachine Canal and leads to Lock No. 3, with a lift varying from 1 to 7 ft. to the level of Lake St. Louis. The canal enters the lake about 2 miles further west, from which point the excavation of a channel is necessary for several miles before deep water is reached.

The plans provide for locks 860 ft. long and 80 ft. wide, which are the dimensions adopted for the New Welland Ship Canal, now under construction, between Lake Erie and Lake Ontario. The canal sections are to be excavated to a minimum bottom width of 200 ft. through cuttings and 450 ft. in the river channels, which is the width of the Ship Channel below Montreal. A dam and power house is shown in Fig. 6. The dam will control the flow and may be utilized to maintain a low water level in Lake St. Louis 5 ft. or so greater than at present without raising the maximum elevation, as well as to provide the increase in depth when the change is made from 25 ft. to 30 ft. navigation.

The 30-foot project is estimated to cost about 70 million dols., and the power plant about 85 million dols. more, though these estimates do not appear to include interest during construction and certain other overhead charges. The amount of power to be obtained is estimated to be about 700,000 h.p. in summer, but less in winter due to the ice jams in the river below, which makes this one of the most expensive and least attractive of the different sites available. In any case it should be deferred until the development has been carried out in the second reach between Lakes St. Francis and St. Louis.

Lake St. Francis to Lake St. Louis.—In this stretch the conditions are unusually favourable to the side canal method. Between the two lakes, on both sides of the river, there is a level bench of land for nearly the whole distance, which lends itself to easy canal construction, and in which the total fall is largely concentrated near the lower end where the main lift locks may be conveniently located. It is, of course, possible to canalise the river, but important plants already existing would be interfered with, and the cost would be otherwise excessive.

The Government plans offer two methods of development, both of which are indicated in Fig. 7. In one of these the navigation and power projects are to be carried out as two entirely separate schemes. Navigation is to be provided for by a side canal on the south side of the river, as shown. A double twin flight of locks, Nos. 4 and 5, are located at the lower end near Melocheville on Lake St. Louis, which will raise the water level to that of Lake St. Francis. A guard lock, No. 6, is located at the Lake St. Francis end, where a dredged channel, with a jetty to prevent cross currents, is carried out for some distance into the lake. The cost of a 30 foot navigation canal is given as about 40 million dols. The power development is shown on the opposite side of the river. It consists of a dam across the river between the Coteau and Cedar Rapids, which would drown out the former and bring the Lake St. Francis level down to the entrance of a power canal leading to a power house just north of Cascades Point, where over 1,600,000 continuous horse power can be developed with the whole flow of the river available. Some excavation would be necessary through the crest of the Coteau Rapids. The estimated cost of this development is given as 152,000,000 dols.

The other method of development considered is also shown in Fig. 7. In this case both power and navigation canals are on the north side of the river as shown, and the dam serves both purposes. At the Lake St. Louis end there is a lock, No. 4, with a lift of 39 ft., followed as shown on the profile (Fig. 7A) by another lock, No. 5, of about the same lift. Near where the canal enters the river there is a guard gate, and a partial regulating dam and low lift lock, No. 6, are located near the end of the Coteau Rapids. The estimated cost of the combined navigation and power schemes is given as about 12,000,000 dols. less than by the first scheme, if both were carried out at the same time, and about as much more if built separately.

Prescott to Cornwall.—The general physical features in this stretch of the river have already been shown to differ from those of the two lower stretches. The total fall is distributed over a distance of nearly 50 miles and, between the three main rapids, the river is navigable in both directions. Investigations carried on for several years by the Hydro-Electric Power Commission of Ontario in connection with projects for the development of the entire flow of the river for power, have shown that many of the works necessary for this purpose will also serve for the canalisation of the river which is the method of improvement most suitable to the natural conditions. This conclusion was also reached by the Deep Waterway engineers when studying the question primarily from the point of view of navigation. There are several other reasons why this stretch should be considered in a separate category. For example, it is for its entire length

* Read before Section G of the British Association at Toronto, on August 8, 1924.

the international portion of the river, in which the power belongs jointly to Canada and the United States, and where the development involves co-operation on the part of both countries. It is also the portion of the river which lies within the boundaries of the Province of Ontario, where the general policy of power development is quite different from that of the Province of Quebec, through which the rest of the river flows. Its improvement is the next step, following in natural sequence the completion of the New Welland Canal in the Deep Waterways project, and the drowning out of the rapids should begin at the upper end of the river on account of the protection from ice thus afforded in the construction and operation of works lower down. And, finally, there is a pressing demand in both countries for all the power available as fast as it can be developed.

Two general methods of improvement are possible, a double development scheme and a single development scheme. In the former, the works would be carried out in two stages, the upper of which would include the Galops Rapids and Rapide Plat, and the lower the Farran's Point and Long Sault Rapids. By this method the river would be confined to as great an extent as possible within its present banks, with practically no flooding below Morrisburg. In the single development scheme the entire fall available for power would be concentrated at the foot of the Long Sault. There would be a regulating dam at the Rapide Plat to control the outflow from Lake Ontario. This method will cause considerable flooding and requires the construction of long and high wing dams, and a number of embankments of various heights.

Single Stage Development.—Figs. 8 and 8A show in a very general way a single stage development very similar to that proposed by the Government engineers. As in all schemes for the improvement of the river, a large amount of excavation is required through the Galops Rapids and at various points between there and Morrisburg, in order to secure suitable depths and velocities for navigation and the highest practicable pool level at the dams below. This enlargement of the river channel will necessitate some means of controlling the flow, and this is provided by regulating dams at the Rapide Plat across the channels on each side of Ogden Island. With the water at Elevation 245 above the Galops, a normal water level of about 242 can be maintained above the Ogden Island dams. There will be a navigation lock, No. 9, on the United States side with a maximum lift of 10 ft. to 12 ft. From Morrisburg to the Long Sault, no channel improvements will be required.

The foot of the Long Sault Rapids is at the lower end of Barnhart Island, and it is near this point that the power plant of the single stage development must be placed in order to utilize the available head. It is impossible to make use of the adjacent shores of the river at this point as they are much too low for the purpose. Fortunately, however, Long Sault Island and both Barnhart and Sheek Islands are considerably higher, and it is only by taking advantage of this circumstance, and by carrying the pool level down between the two latter islands, that a single development becomes practicable.

The normal elevation of the water surface above the Long Sault Rapids is 202, and below the proposed power plant, 155. The proposed pool level is 231, though the power house and other structures are to be designed to permit this to be increased by 8 ft. or 10 ft. The Little River is the shallow channel which separates Sheek and Barnhart Islands. It carries less than 5 per cent. of the total flow and leaves the main channel in the middle of the rapids where the water surface is at elevation 175. Just below this there is to be a spillway dam about 3,800 ft. long, connecting Barnhart and Long Sault Islands, and provided at each end with a set of Stoney sluices. Its crest will be at elevation 231, and it will, therefore, serve to divert the main flow into the channel of the Little River and down to the power plant. In order to retain this pool level, a series of lateral dams and embankments are necessary starting from both ends of the power plant. On the north side a retaining wall and embankment over 8,000 ft. long and 100 ft. high connects it with Sheek Island, the upper end of which is, in turn joined to the north bank of the river by heavy embankments with core walls. On the south side the pool level is carried by way of Barnhart Island, the Spillway dam, Long Sault Island, and a dam and power house at the upper end of the South Sault Channel, to the main shore of the river. The main shores themselves, for miles further upstream on both sides require embankments at a number of points to maintain the required elevation.

The most important of the structures just referred to, is the spillway dam, which crosses the river at the swiftest and deepest part of the rapids, and which is estimated to cost upwards of 11,000,000 dols. The power house at the head of the South Sault Channel is to utilise, under a head of about 28 ft., the water required for the existing Massena power plant, which is supplied from this channel by a power canal 3 miles long, and which discharges into the Grasse River, a tributary flowing at a much lower level.

Navigation is carried from the river at Cornwall up into the pool and past these works by about 7 miles of canal, and two locks, Nos. 7 and 8, located as shown in Fig. 8, and with lifts of 48 ft. and 31 ft. respectively. At the proposed power plant at the foot of Barnhart Island, there will be a Canadian and an American power house. To provide better for the handling of floating ice, these power houses should be placed more nearly parallel to the direction of the current than shown, and space for a number of sluices should be left between their lower ends. Their combined length is about 3,400 ft., sufficient to provide for a total installed capacity of about 1,780,000 electrical horse-power in units of about 34,000 e.h.p.

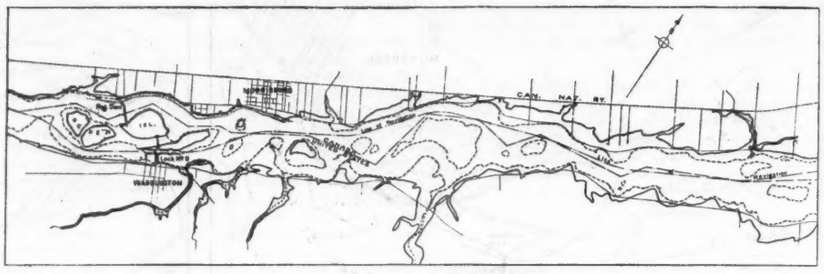
While it would considerably increase the lateral dams and embankments required, as well as the area flooded, it is quite feasible to maintain a pool level 8 ft. or 9 ft. higher than that adopted for this scheme of development. This elevation, which is that of the crest of the spillway of the main dam, was really determined by the conditions expected to obtain during the winter in the river above the works. Above the Morrisburg dam the enlargement of the channel and the raising of the water level, will considerably reduce the velocity of the current, but it will still be so great as to prevent the river freezing over even in the severest winter. Below Morrisburg, however, a complete ice cover will form at the lower end early in the winter, and extend upwards on the whole pool, and as this will be largely composed of packed ice, a considerable increase in slope is inevitable. The drowning out of the rapids will, in itself, greatly reduce the formation of frazil and anchor ice, especially the latter, which does not readily form in water over 25 ft. or 30 ft. in depth. Yet, in the stretch of open water from Prescott down, a considerable quantity will still form, especially during periods of severe cold. This will lodge beneath the rough ice cover already formed, and will still further reduce the pool level at the lower end. Whether this reduction will or will not exceed the amount allowed for it is difficult to say, but that it will occur every year is certain. On the other hand, the back water from jams starting at the head of Lake St. Francis will, no doubt, be considerably reduced though not by any means entirely prevented. A certain amount of slush ice will still be formed in the open water below the dams and power houses at all times, and in the beginning of the winter, before the ice cover in the river has permanently formed, there will be a period during which the conditions are particularly favourable to the formation of anchor ice and frazil, all of which will pass down to begin the formation of the jams below. In any case, the fixing of the pool level at an elevation which will entail the permanent sacrifice of between 100,000-h.p. and 200,000-h.p., summer as well as winter, whether by reason of the unavoidable winter drop in pool level, or the flooding of too much land, or the risk of depending on so many long and high embankments, is undoubtedly a very serious feature of this method of development.

Double-Stage Development.—The essential difference between this method and the single-stage development is that instead of the regulating dam at Morrisburg there will be a combined control and power dam, and a power plant of about 620,000 h.p., operating under a head of 28 ft. There will be a Barnhart Island power-house in about the same location, but with a pool level of 210 instead of 231. The river improvements as far down as the head of Ogden Island are identical. At that point the navigation channel continues down the present main river channel north of this island, instead of following the Little River channel on the south side, as in the single development. This Little River at one time carried about 10 per cent. of the total flow, but has been closed by a dam for many years.

The main dam is between Ogden Island and the north shore, and, in addition to a section of free spillway, is provided with a set of Stoney sluices and a number of submerged sluices for winter regulation. There is a second, shorter regulating dam between the lower end of the power plant and the south shore.

The two power-houses are in line with each other and parallel with the general direction of the flow, which is the best possible arrangement as far as the avoidance of ice troubles at the plant is concerned. The over-all length is about 4,300 ft., sufficient to accommodate 66 units of 11,000 e.h.p. capacity. Plans are being worked out, however, at the present time, to employ units of about this capacity, which will considerably shorten the over-all length and improve the lay-out in other ways. The lock, No. 9, will be located at the north end of the main dam, and will have a lift of 28 ft.

Extensive channel improvements will be made



Full Lines indicate Regulated Shore Lines
Dotted Lines indicate Present Shore Lines

Fig. 8. SINGLE STAGE DEVELOPMENT
From Morrisburg Regulating Dam to Barnhart Island Power House

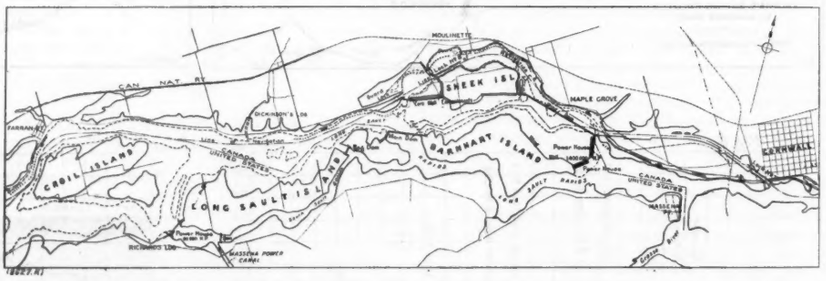
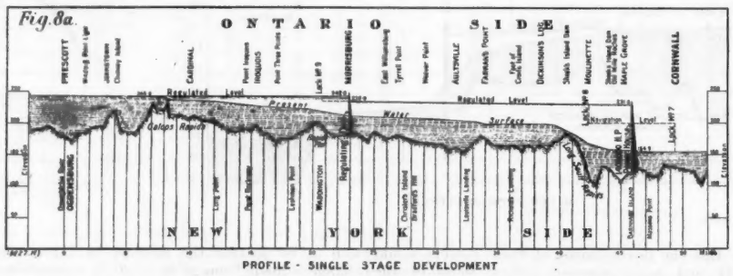


Fig. 8a.

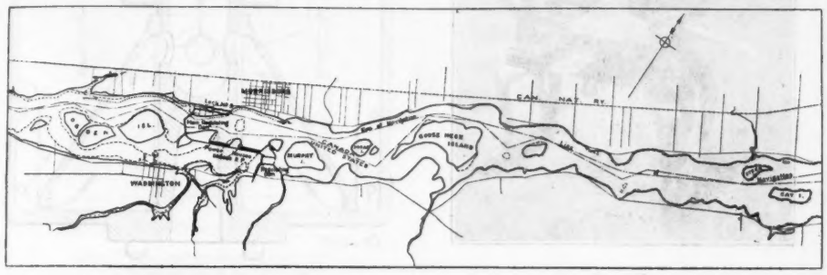


PROFILE - SINGLE STAGE DEVELOPMENT

between Morrisburg and Barnhart's Island to obtain the required navigation depths and velocities, but this will be largely at the upper end of the stretch. At the lower end the location of the main dam and the power houses will be substantially the same as in the single development, though they will be much lower, as the head at the power plant will be 55 instead of 75 ft. There will be no dykes or embankments and no power-house at the head of the Long Sault, nor will there be any necessity for the long and high retaining wall between the north end of the power plant and Sheek Island.

Lock No. 7 and the river improvements below will be exactly as in the single-stage scheme, but the canal will be located a little further to the north, and Lock No. 8, with a lift of 10 or 12 ft., will be located at the eastern end of the pool north of Sheek Island, from which the line of navigation will follow the main channel of the river to Morrisburg.

At the double-development power house at the foot of Barnhart Island, it is proposed to maintain a constant forebay level of 210. The lay-out in Fig. 9 shows two power houses with a dam and ice sluices about 800 ft. in length separating the lower ends. As shown they have a total length of 3,100 ft., designed to accommodate 50 units each of a capacity of 25,000 e.h.p. This power house can be supplied by the channels on both sides of Sheek Island.



Full Lines indicate Regulated Stage Lines
Dotted Lines indicate Present Stage Lines

Fig. 9. DOUBLE STAGE DEVELOPMENT from Morrisburg Dam and Power House to Barnhart Island Power House.

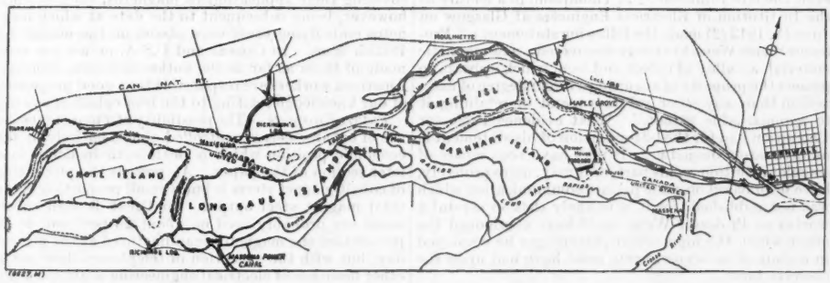
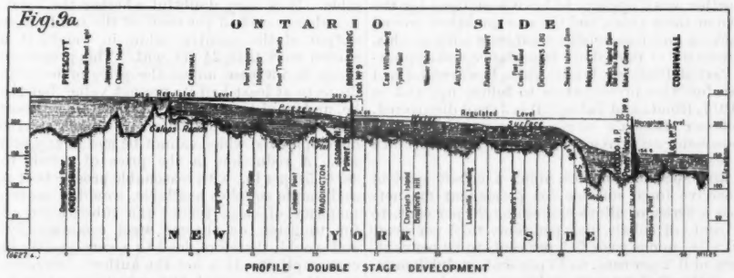


Fig. 9a.



PROFILE - DOUBLE STAGE DEVELOPMENT

The profile (Fig. 9A) shows that in the double development the pool levels conform fairly closely to the natural profile of the river, the principal increase in height being at the power houses which are at the foot of the rapids. In other words, this method of development is in harmony with the actual physical conditions, and, as a consequence, the river as a rule does not overtop its present banks. Such flooding as there is will be almost all above Morrisburg, where it will be exactly the same as in the single development.

With regard to ice effects there is a decided difference between the two methods. Down as far as Morrisburg and below the Barnhart Island works, the conditions under both methods will be the same at all times; and in the beginning of the winter before the lower pool of the single development freezes over there will be practically no difference anywhere. But from Morrisburg to the head of the Long Sault the natural level is raised so little in the double development, that navigable velocities are secured in many places only by enlarging the channel. Hence, this portion of the river will remain open as at present so far as the main channel is concerned, but the bordage ice will probably extend further out and cover a relatively greater area.

As has been stated before, the drowning out of the rapids and the deepening of the main channel will greatly diminish the formation of anchor ice and frazil; but, with the continuous open channel throughout the pools which will be maintained under the double development, the quantity which does form will in part accumulate in the bays and eddies, but largely, no doubt, will be carried on downstream to the river below Barnhart Island, and assist in the formation of the jams which cause backwater. On the other hand, special observations, which are confirmed by the regular winter gauge readings, show that the bordage ice has little effect on the slope of the river. Hence, whatever loss of head may result from the action of ice in the double development scheme, will be very largely due to backwater. This will, of course, be much less than under present conditions, and in some years will be almost negligible. The gauge records show that it will never be felt in the tailrace to any great extent until late in January after the peak of the power demand has passed. Furthermore, there is undoubtedly an important element of security in the fact that the accumulations of ice which cut down the power are formed in the river below the plant instead of in the pool above.

Estimates of Cost.—Estimate of cost of the entire navigation and power works were made by the Hydro-Electric Power Commission of Ontario on the assumption that they would be carried out as one continuous series of operations. This was done in order that they might be directly compared with those of the Government engineers which were made on that basis. Based on 1921 conditions, the total estimate for the single development was a little less than 210,000,000 dols., and for the double development about 150,000,000 dols. more. Making allowances for the omission of certain items the Government estimate for the single development (the only one considered), would be about 10 per cent. lower.

A tentative apportionment of the total cost of each of the schemes to power and navigation was made by the Hydro-Electric Commission on the basis of charging to each project the full cost of works required exclusively for its particular purposes, and of dividing equally between the two, the cost of such works as would serve the purposes of both. On this basis, the part chargeable to navigation was about 33 per cent. for the single development and 27 per cent. for the double development. Other estimates were of course made of the cost of carrying out the works, more in accordance with the probable conditions and requirements, all of which indicate a comparatively low cost per horse-power and per kilowatt-hour.

Power Available.—The quantities of power available at the different sites, which have been mentioned in the foregoing, refer to 24-hour power which could have been depended upon year in and year out for practically the whole period of observation. Considering, however, the extraordinary regularity of the flow, and the magnitude and diversity of the power demand in the extensive distribution systems with which these plants would be connected, the power which can be developed and utilised commercially at its full value may be very conservatively estimated as at least 25 per cent. greater than the figures given. This means that the potential power of the St. Lawrence is about 5,000,000 h.p., and of this about 4,000,000 h.p. belongs to Canada.

Nowhere else in the world is there a group of closely associated powers of such magnitude and so advantageously located. Close to the two largest cities, the greatest ocean port, extensive industrial and mining areas, they are actually within transmission distance of half the population of the country. The adjacent districts are served by the principal railway lines, and water transporation is available to the centre of the Continent and to all parts of the world. Under such incomparably favourable conditions, the mere development of power at low cost would in itself attract industries of all kinds, and especially those requiring hydro-electric energy in large quantities, with reasonable assurance of an adequate future supply. Wisely developed, and utilised in the country where it belongs, this power will undoubtedly rank as one of Canada's most valuable assets, and indeed may well become an asset of value to the whole Empire.

THE SPERRY GYRO COMPASS.—This equipment appears to be finding favour in recent steamship practice, a number of newly-designed ships having provision made for mounting the apparatus. Although not yet completed, the vessels Aorangi, Aurania, Alannia, Ascania, Caledonia, Gripsholm and Servia are among these, while the Olympic, Homeric, Lord Kelvin, among others, are already so fitted. The Servia and Wandsworth Works will, in addition to the gyro compass, be fitted with the Sperry gyro pilot and helm-angle indicator, with which equipment the Empress of France beat her own previous west-bound speed record made before being so fitted.

THE INSTITUTE OF METALS.—This institute has issued the programme of its Autumn Meeting which is to be held from September 8 to 11. The third annual Autumn lecture will be delivered on the 8th, at 8 p.m., in the Hall of the Institution of Mechanical Engineers, by Mr. W. M. Corse, of the National Research Council, Washington, U.S., on "Recent Developments in Non-Ferrous Metallurgy in the United States, with special reference to Nickel and Aluminium Bronze." On the 9th and 10th, the following papers will be read and discussed:—1. Mr. Robert J. Anderson (Boston, Mass., U.S.A.) and Mr. G. Fahlman Everett (Cleveland, O., U.S.A.), "A Method for Measuring Internal Stress in Brass Tubes." 2. Mr. D. H. Andrews and Professor John Johnston (New Haven, Conn., U.S.A.), "The Application of the Ideal Solubility Curve to the Interpretation of Equilibrium Diagrams in Metal Systems." 3. Dr. Guy D. Bengough and Mr. R. May (London), "Seventh Report to the Corrosion Research Committee of the Institute of Metals." 4. Mr. E. H. Dix, Jr., and Lieut. A. J. Lyon (Dayton, O., U.S.A.), "Comparative Results on Copper-Silicon-Aluminium and Other Aluminium Alloys as Obtained on Separately Cast Specimens and Specimens cut from a Crankcase Casting." 5. Mr. D. M. Fairlie and Mr. G. B. Brook (Kinlochleven). "The Determination of Sodium in Aluminium." 6. Mr. R. Genders (Woolwich), "The Extrusion of Brass Rod by the Inverted Process." 7. Dr. D. Hanson and Miss Grace W. Ford (Teddington), "Investigation of the Effects of Impurities on Copper, Part II.—The Effect of Iron on Copper." 8. Mr. Douglas H. Ingall, "The Relationship between Tensile Strength Temperature and Cold-Work in Some Pure Metals and Single Solid Solutions." 9. Mr. H. Moore (Woolwich), "On the Effect of Progressive Cold-Rolling on the Brinell Hardness of Copper." 10. Sir Thomas K. Rose and Mr. J. H. Watson (London), "Experiments on the Working of Nickel for Coinage." 11. Mr. Francis W. Rowe (Manchester), "Some Experiments on the effect of Casting Temperature and Heat-Treatment on the Physical Properties of a High-Tin Bronze." 12. Mr. Francis W. Rowe (Manchester), "Some Experiments on the Influence of Casting Temperature and Mass on the Physical Properties of Admiralty Gun-Metal." 13. Mr. Tomojiro Tanabe (Osaka, Japan), "Studies in the Aluminium-Zinc System." 14. Mr. T. Henry Turner and Mr. W. E. Ballard (Birmingham), "Metal Spraying and Sprayed Metal." Visits are to be paid to several works, to the British Empire Exhibition, to the National Physical Laboratory and to Windsor.

THE "MONARCH" CENTRIFUGAL OIL PURIFIER.

PROBABLY no commodity essential to engineers yields possibilities of greater economy than lubricating oil, and the various devices on the market for the purpose of purification of waste oils indicate the attention given to the subject. Of these means, the simple filtration method is slow and suitable only for certain grades of oil. Designed to overcome these disadvantages, the "Monarch" centrifugal oil purifier, introduced by Messrs. O. N. Beck, of 11, Queen Victoria-street, London, E.C.4, and which is shown in Fig. 1, operates on the principle that those portions of a mass of oil, or oil contaminated with water, in a rotating container which are of greatest density will be found nearest the circumference, and the lightest parts nearest the axis of revolution. The machine consists in the main of three parts; the stand with a driving arrangement; the drum pan, screen and receptacle for the impure oil; and the heating equipment. Dealing with the first, the stand for the belt drive carries the brackets for the pulleys and striking gear on one hand, and the drum pan with gut drive pulleys on the other. The fast and loose pulleys have a diameter of 7⅞ in. and a width of 2 in. They should be so connected to the counter shaft that they have a speed of 45 revolutions per minute, since higher speeds cause excessive strain on the drum. An electric motor can be supplied to suit any current and voltage should this type of drive be desired, the arrangement remaining otherwise the same as for the belt drive.

A vertical section through the drum, the vital part of the machine, is shown in Fig. 2. The filter is composed of two horizontal fine meshed wire sieves between which is a corrugated body filled with glass wool. In the middle of this filter there is a further central filter filled with glass wool. The heating arrangement consists of a coiled steam pipe common to both the receptacle for the dirty oil and the drum pan, not shown in Fig. 2. A modification is supplied utilising electricity to heat the oil when steam is not available. The mode of operation is as follows: Dirty oil is supplied to the top receptacle (Fig. 1); this is warmed and passed down the vertical central passage in the drum (Fig. 2). Centrifugal action sends the heavier impurities against the coned distributor below which it passes upwards on to the filter. The separator then comes into play, trapping any water in the passage near the drum circumference, while the cleaned oil passes through the central filter to the upper outlet. Water being heavier than the oil, naturally travels to the outer passage and so out of the machine by the lower outlet. Particles of metal and heavy impurities will settle on the drum, on the distributor and on the oil filter. The drum and distributor must be properly cleaned after each operation. Two sizes of the purifier are available, having capacities of 11 gallons and 22 gallons per hour respectively.

CENTRIFUGAL OIL PURIFIER.

MESSRS. O. N. BECK, ENGINEERS, LONDON.

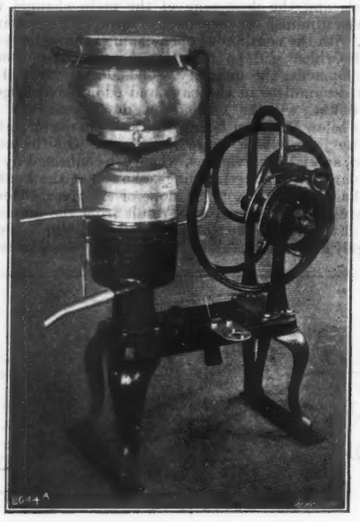
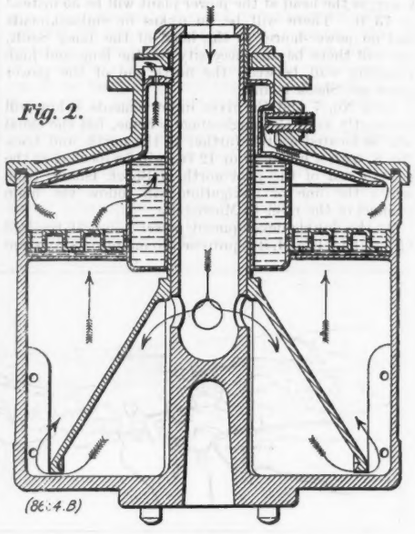


FIG. 1.

Fig. 2.



COBALT MAGNET STEELS.*

By E. A. WATSON, M.Sc.

Historical.—Although previous work on the magnetic properties of cobalt and its alloys with iron had been carried out by a number of investigators, the first occasion on which the magnetic properties of the iron cobalt alloys were clearly set forth was in a contribution by Professor P. Weiss to a symposium "On the Magnetic Properties of the Alloys of the Ferromagnetic Metals," held by the Faraday Society on April 23, 1912 (1). On this occasion Professor Weiss read a paper, which, among other investigations, described the researches of Preuss and himself into the magnetic properties of the iron cobalt alloys, and in particular on their intrinsic magnetisation at absolute zero, or, as Professor Weiss terms it, their "specific saturation." In this paper he shows the existence of an alloy Fe_2Co with a specific saturation some 10 per cent. greater than that of iron itself, and he further shows that this alloy is capable of forming a continuous series of solid solutions with metallic iron, the members of the series possessing intermediate properties dependent on the amount of cobalt present. Professor Weiss did not in this paper, however, make any reference to the effect of cobalt on the properties of iron-carbon alloys, nor did he give any data for the properties of his alloys, other than the specific saturation and the Curie constant.† It would seem possible, therefore, that the very marked effect of cobalt on the coercive force of an iron carbon alloy had escaped his attention. On the other hand, however, the late Professor S. P. Thompson, in a lecture to the Institution of Electrical Engineers at Glasgow on June 13, 1912 (2) made the following statement: "Professor Pierre Weiss has lately discovered a new magnetic material, an alloy of cobalt and iron, which appears to possess the property of acquiring a larger degree of magnetism than any other substance, and of retaining it to a remarkable extent." What evidence Professor Thompson had for the latter portion of his statement is unfortunately denied us. It may have been a case of singular intuition on his part, or it may, more probably, have been based on some private communication which was not published, for it is unlikely that so careful a worker as Professor Weiss could have overlooked the effect which the high cobalt percentages he employed in certain of his experiments must have had upon the coercive force.

No further work appears to have been done for the next two or three years, and the war doubtless proved a setback to any researches on subjects such as this, which were not of immediate importance and application. Part of Professor Weiss' work, however, formed the basis for other investigators to follow up, and in June, 1917, Honda and Takagi (3) in Japan discovered, in Professor Honda's words, "a remarkable steel alloy possessing an extremely high coercive force, and a strong residual magnetism."

The first specification describing a cobalt steel of high coercive force suitable for permanent magnets describes a series of alloys containing 20 per cent. to 60 per cent. of cobalt, 0·3 per cent. to 2 per cent. carbon, with, in one case, 0·5 per cent. to 20 per cent. tungsten, or 0·2 per cent. to 15 per cent. molybdenum, and in another 0·3 per cent. to 10 per cent. chromium. In a more recent article describing these steels, Honda and Saito give suitable compositions of: Carbon, 0·4 per cent. to 0·8 per cent.; cobalt, 30 per cent. to 40 per cent.; tungsten, 5 per cent. to 9 per cent.; chromium, 1·5 per cent. to 3 per cent. The work of Weiss and Honda undoubtedly formed the foundation on which a number of British steel firms developed cobalt magnet steels to a commercial scale during the years 1919-1923; although development did not in every case follow the same lines, certain firms developing steels with approximately 35 per cent. of cobalt and aiming at the maximum possible magnetic value, more or less regardless of cost, while others concentrated their attention on producing a steel which, while giving magnetic results much superior to tungsten or chrome steels, should do so at a reasonable cost. Further reference to the different classes of steel evolved will be made at a later point in the paper.

Present Production.—The total production of cobalt magnet steels by British firms is roughly estimated at 100 tons of steel per annum, utilising from 20 tons to 25 tons of metallic cobalt. Of this quantity probably about 60 per cent. is represented by the air hardening cobalt chrome steels, the remainder being accounted for by the other steels described in the paper. As far as is known, the steels are not being manufactured in bulk in any country other than Great Britain. Experiments in connection with them have been tried in Germany, and the firm of Robt. Bosch has filed patents covering their application to magnetos, such patents, however, being subsequent to the date at which magnetos embodying them were placed on the market by British firms. In Canada and U.S.A. no use has been made of them as far as the author is aware, although American workers are responsible for a good proportion of our knowledge relating to the iron cobalt alloys (4).

Future Prospects.—The possibility of a more extended use of cobalt steels is controlled almost entirely by the economic position which is dealt with in detail in a later section of the paper. At present the production of cobalt magnet steels is but a small proportion of the total magnet steel output. In Great Britain cobalt steels are probably used on about 25 per cent. to 30 per cent. of the magnetos manufactured at the present day, but with the exception of telephones their use in other branches of electrical engineering is almost negligible. It is very doubtful whether the total output in value exceeds 5 per cent. of the total magnet steel output of the country, while in weight it will not exceed more than 2½ per cent. This proportion is not likely to increase unless the price of metallic cobalt drops to at least half its present value, but there may be, under existing conditions, a certain increase in output due to the application of cobalt steel to fresh developments, which cannot be met in any other manner. A reduction in the price of cobalt to about 4*s.* to 5*s.* per lb., with reasonable prospects of stability, and ample supplies available, would, however, in the majority of cases render the substitution of cobalt for tungsten or chrome steel economically sound, and would, therefore, lead to a very greatly increased consumption. It is not the author's intention to discuss the question of the possibility of such a price reduction, but he hopes that this paper, being read so close to one of the principal centres of cobalt production in the world, may have the effect of elucidating some information on this most important problem.

Effect of Cobalt Content on the Properties of Magnet Steels.—In a carbon-free iron-cobalt alloy the effect of adding increasing quantities of cobalt is to produce an increase in the specific magnetism, or intensity of magnetisation up to a maximum with 35 per cent. cobalt, after which it again decreases. This effect, as already mentioned, was first observed by Weiss and Preuss, who ascribed the presence of this maximum to the formation of a definite alloy Fe_2Co. Later, K. Honda (5) has confirmed Weiss' figures for intensity of magnetisation, which he finds increases from a value of approximately 1,700 for pure iron to 1,900 for the 35 per cent. iron cobalt alloy, decreasing again to 1,200 for pure cobalt. Professor Honda, however, does not admit the existence of a definite alloy Fe_2Co as the iron cobalt equilibrium diagram gives no evidence in support of this.

It is further noteworthy that Professor Honda's researches on the thermal and electrical resistivities, and on Young's modulus and the modulus of rigidity for the iron cobalt series show no such well-defined maximum at 35 per cent. cobalt.

Professor Honda explains the peak normally found

* Paper read before Section G of the British Association at Toronto on August 13, 1924.

† The Curie constant of a para-magnetic material is equal to the susceptibility per unit of mass multiplied by the absolute temperature. In ferro-magnetic materials this constant only applies at temperatures above the A_2 point.

at 35 per cent. cobalt by assuming that the true value of the intensity of magnetisation for pure iron is not the usually accepted figure of 1,700, but is approximately 2,200 and that for some reason, which is not understood, the true saturation value of magnetisation of pure iron is never attainable. In his view, apparently the true value of I_s follows a straight line law, varying from 1,200 for metallic cobalt to 2,200 for pure iron. The true value of I_s is attainable provided the percentage of cobalt is in excess of 35 per cent., but as the cobalt content is reduced below this the attainable value of I_s falls below the true value by

Fig.1. MAGNETIC PROPERTIES OF TYPICAL LOW ALLOY STEEL

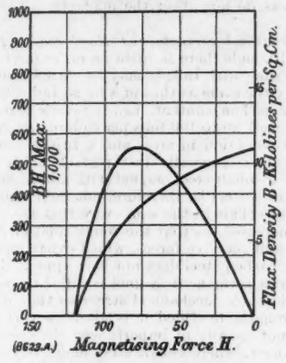


Fig.2. MAGNETIC PROPERTIES OF TYPICAL MEDIUM ALLOY COBALT STEEL. 35 PER CENT COBALT.

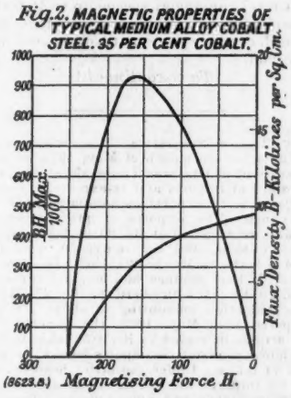
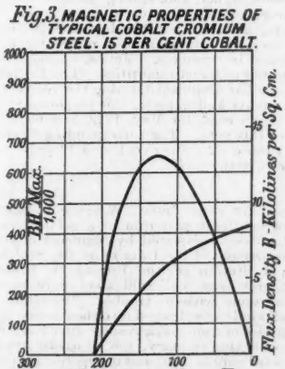


Fig.3. MAGNETIC PROPERTIES OF TYPICAL COBALT CROMIUM STEEL. 15 PER CENT COBALT.



successively greater amounts, until for pure iron it reaches only the value of 1,700. This explanation, it must be admitted, sounds a little weak, but it is certainly significant that the other properties of the iron cobalt series show no similarly-situated maxima or minima. In a magnet steel, however, the Weiss effect is of little importance; although it probably occurs, it is small compared with the effect of cobalt upon the coercive force, and hence upon the capacity of the magnet as a source for the storage of energy. Moreover, it is in general masked by other changes in the composition or structure of the steel.

The intensity of magnetisation of a magnet steel is rarely in excess of 1,300, owing probably to the difficulty of obtaining the whole of the iron in the magnetic state without permitting any carbide segregation. This means that normally about 30 per cent. of the iron present is non-magnetic. A comparatively small change in the amount of non-magnetic iron present, such as may be induced by variations in the heat treatment, or alloy content, is sufficient to offset the increased magnetisation of the magnetic portion. Consequently, although the Weiss effect can be traced, if care is taken to ensure that other conditions are unchanged, it is not correct to assume that a cobalt steel in general has either a higher saturation density or a higher remanence than the ordinary tungsten or chrome steel of commerce. As a matter of fact, it is usually lower, although probably not lower than that which would be given by a magnet steel free from

Fig.4.

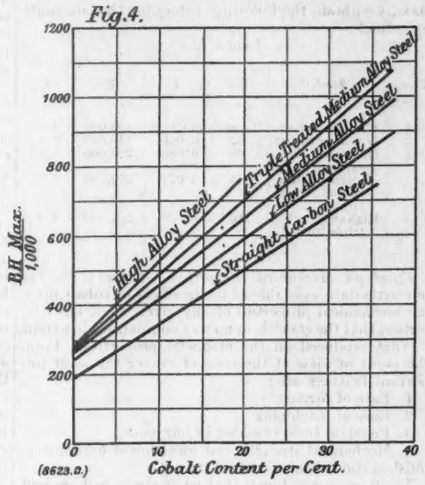
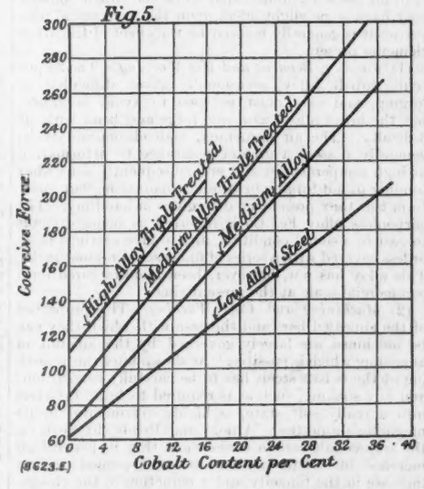


Fig.5.



cobalt, which had been produced to give the maximum possible value of BH max.

Importance of BH max.—Recent work (6) has shown that the true criterion of a permanent magnet is not the remanence, nor the coercive force, nor even the product of these two, as has sometimes been assumed, but is the maximum value of the product of B and H, taken at various points along the demagnetisation loop. This represents the maximum energy which the magnet can provide in a circuit external to itself. In an apparatus such as a magneto, where the magnet goes through a cyclic change, and is used to provide a means for the storage of energy it represents the maximum amount of work which can be stored up at each cycle of operations. A properly designed magnet will, therefore, work at the point at which BH is a maximum. With ordinary steels this will be found to occur at a point where $H = H_c [\sqrt{r^2 - r} - r]$ where r is the ratio of B_s to B_{rem}. The value of r usually changes between 1·5 and 1·6 so that $\frac{H}{H_c}$ varies between the corresponding values of 0·635 and 0·62. For all practical purposes it is sufficiently accurate to say that BH is a maximum when $H = 5/8\ H_c$.

The ordinary tungsten and chromium steels of commerce were all developed at a period when the significance of BH max was not realised, and when the designer's one aim was to obtain the maximum flux possible from a given section of steel, while at the same time providing sufficient magnet length to make the magnet reasonably permanent. This probably led to the development of remanence at the expense of BH max. The cobalt steels on the other hand are all of recent development, and the importance of BH max has been generally recognised in connection with them. Consequently, there has not been an undue importance attached to the attainment of the highest possible B_{rem}. The effect of cobalt on the coercive force of a steel is very much greater than the effect on its saturation density, for whereas the latter does not at the most exceed some 10 per cent. for a cobalt content of 33 per cent., the former usually amounts to at least a threefold increase for the same cobalt content. It seems strange indeed that this most important effect should have passed unnoticed by all the early workers on the cobalt alloys, and in particular on the alloy Fe_2Co. Mr. J. F. Kayser (7) who was responsible for a large amount of the original development work on the cobalt-chrome series of steels, has suggested the following formula as expressing the relation between coercive force and cobalt content—

$$H_c = H_o (1 + kC) \quad . \quad . \quad . \quad (1)$$

where H_o is the initial coercive force of a cobalt free steel, k a constant and C the cobalt percentage present.

The formula could possibly be written more correctly as—

$$H_c = H_o (1 + k_1 C_1) \quad . \quad . \quad (2)$$

where k_1 is a constant and C_1 is the percentage, not of cobalt, but of the alloy Fe_2Co. The cobalt chromium series investigated and developed by Mr. Kayser have the following general analysis—

	Per cent.
Carbon	1·0
Chromium	9·0
Molybdenum	1·5
Cobalt	0—20

for these alloys the constants in (1) have the values

$$H_o = 110$$
$$k = \cdot 056$$

Such an alloy will give, therefore, with a cobalt content of 15 per cent. a coercive force of 205, while with 9 per cent. of cobalt a value of 166 can be obtained. It is not possible, however, to continue this series of alloys to cobalt contents in excess of about 20 per cent. owing to a difficulty in breaking down the austenite in hardening steels of this class, where the cobalt content is in excess of this figure. This will be referred to further later.

While a number of other steels containing cobalt have been developed it would appear doubtful whether their development has been accompanied by any organised research correlating cobalt content and magnetic properties. They form, therefore, a series of isolated points, differing not only in cobalt content, but in the contents of carbon, tungsten, chromium, &c., in addition. It may, however, be assumed that each represents the best result attained by some particular worker in following up a definite line of attack. During the last four years a large number of steels have come under the author's observation generally in the form of samples submitted by steel makers for testing purposes. As in many cases the analysis was given as confidential it is not possible to publish the composition of the majority of the steels, for which data is available. They cover, however, a large range of materials, from a straight carbon steel, in which a portion of the iron is substituted by cobalt, to complex steels containing chromium, tungsten, molybdenum and other alloying elements. It is possible, however, to make a rough sub-division in to various classes, and on the basis of this sub-division to obtain curves showing approximately the effect of cobalt on a given type of steel.

The classification adopted is as follows:

(1) "*Straight Carbon*" *Steels, i.e.*, steels containing iron cobalt and carbon only as their chief constituents. These steels are invariably water hardening, and generally require the use of brine or iced water to obtain the best results. The first cobalt steel produced in England, and marketed as such belonged to this class, but as the results are relatively inferior, and the hardening difficulties are serious the steel is not now employed.

(2) *Low Alloy Steels.*—These steels contain chromium, tungsten, molybdenum, or their equivalents, in approximately the same proportions as in ordinary tungsten steels. The carbon content ranges between 0·4 per cent. and 0·6 per cent. They usually give a high remanence with a low coercive force, depending, of course, on the cobalt content. Typical steels of this class are described in two patent specifications by Sir Robert Hadfield.

The magnetic properties are given as :—

	a	*b*
Remanence	9,900	10,150
Coercive Force	97	130
BH max (calculated)	375,000	550,000

The analysis is :—

	a	*b*
Carbon	0·52	0·52
Silicon	0·29	0·25
Phosphorus	0·046	0·024
Sulphur	0·058	0·043
Manganese	0·42	0·57
Chromium	2·2	1·85
Nickel	0·51	0·62
Tungsten	8·0	7·82
Cobalt	8·89	17·77

Steel *b* is probably closely allied to the steel which is supplied by Messrs. Hadfields under the trade name of "Permanite," and for which the magnetic properties are given in Fig. 1. These steels are in general water hardening, but owing to the alloy content do not require such a rapid quenching rate as steels of class 1, in order to get the best results.

(3) *Medium Alloy Steels.*—These steels, which are used to a considerable extent, generally contain a slightly higher alloy content than the previous class, and in general a higher carbon percentage. They are usually oil hardening, although water hardening can frequently be employed, without any detriment. They will in general give approximately the same remanence as an ordinary tungsten steel, with, of course, a greatly increased coercive force (Fig. 2). The steel described by Gumlich (8) is fairly representative of this class, though not giving the best attainable results. His composition is given as :—

	Per cent.
Carbon	1·11
Manganese	3·5
Chromium	4·8
Cobalt	36·0

The magnetic properties are given as :—

Remanence, 9310.
Coercive Force, 227·1.
BH max., probably about 825,000 to 850,000.

A typical steel of similar characteristics at present manufactured in Great Britain would have the following approximate analysis :—

	Per cent.
Carbon	0·8–1·0
Tungsten	4
Chromium	5–6
Manganese	1
Cobalt	36

The magnetic properties would be appreciably better than Gumlich's figure, and would be approximately :—

Remanence	9,500–10,000
Coercive Force	240–260
BH max.	850,000–1,000,000

(4) *High Alloy High Carbon Steels.*—These are exclusively of the cobalt chromium class, to which allusion has already been made. They are air hardening steels, containing 9 per cent. and upwards of chromium, with the addition of other elements, such as tungsten or molybdenum and with upwards of 0·8 per cent. carbon (Fig. 3).

A typical steel would have the following analysis :—

	Per cent.
Carbon	1·0
Chromium	9·0
Molybdenum	1·5
Cobalt	15·0

With appropriate heat treatment this steel would give :—

Remanence	8,500
Coercive force	210
BH max.	650,000

Graphical Representation of Foregoing Data.—An attempt has been made in Figs. 4 and 5 to represent graphically the effect of cobalt content on B H max. and on coercive force for the various classes of steel described. No great accuracy can be claimed for it, as with the exception of the cobalt chrome steels the data available is far too scanty and incoherent to enable the relation to be laid down with any degree of exactitude. It is, however, felt that it will give a rough indication of what may be expected from a steel of a given class if other conditions, *e.g.*, hardening, are correct. The relationship has been expressed by a series of straight lines simply because the data is not sufficiently complete to indicate any other form of curve as expressing the relationship more exactly, and because it is known that for the cobalt chrome steels up to 15 per cent. cobalt the linear relation holds fairly closely. Looking at the curves it will be noticed that in addition to its variation with the amount of cobalt present the coercive force depends very greatly on the alloy and carbon content in addition. For example, in a low carbon steel of class 2, 15 per cent. cobalt will only give a coercive force of 120, while the same cobalt in a high alloy high carbon steel will enable a coercive force of 210 to be obtained.

Taking the values of BH max. we find much less variation between different steels of the same carbon content, particularly if we exclude the water hardened, straight carbon steels on the one hand, and the triple treated* steels on the other, although the advantage of keeping the carbon content up to the maximum which it is possible to obtain in solution is clearly apparent. If we express the straight lines on Figs. 4 and 5 by the equations :—

$$H_c = H_o (1 + k\,Co)$$

and

$$P = P_o (1 + k'Co)$$ where P stands for BH max., we obtain the following values for the constants concerned :—

TABLE I.

Class.	Steel.	H_o	k	P_o	k'
1	Straight carbon	Depends on C Con.		190,000	7·9
2	Low alloy carbon	62	0·0615	240,000	7·1
3	Medium alloy carbon	68	0·080	260,000	7·35
	Medium alloy carbon triple treated	85	0·074	270,000	7·9
4	High alloy carbon triple treated	110	0·056	285,000	8·4

Effect on Mechanical Properties.—There is as yet but little data available as to the effect of cobalt upon the mechanical properties of any given steel, but it is certain that the effect is in no way comparable in extent to that produced on the magnetic properties. From the point of view of the magnet maker the most important features are :—

1. Ease of forging.
2. Ease of machining.
3. Freedom from cracking in hardening.
4. Mechanical strength and mechanical hardness in finished condition.

In all cases it is found that while the cobalt content may have some slight effect upon the mechanical properties it is generally masked by the effect of the other elements present.

(1) *Forging, Bending and Hot Working.*—The 35 per cent. cobalt alloy occasionally gives difficulty in forging, and care must be used to avoid breakage, but the lower alloys as a rule forge and bend without difficulty. The air hardening, high chromium steels, generally possess a greater resistance to deformation at high temperatures, and are consequently somewhat tougher in hot forging or bending operations, but apart from this they present no difficulties in handling. The carbonless alloy Fe_2 Co is reported as being difficult to cast in a sound condition, and to give castings more or less covered with a series of fine discontinuous cracks. This alloy has not, however, been manufactured on a commercial scale at the present time.

(2) *Machining and Cold Working.*—The properties of the annealed bars and the ease with which they can be machined are largely governed by the amount of annealing which is possible. As shown later the annealing of the cobalt steels has to be carefully carried out, and any soaking, such as is required to bring the steel into a really soft state, is highly detrimental to its magnetic properties. Arnold and Reads (9) work on the iron-cobalt-carbon series show that in general an increase in cobalt content is accompanied by an increase in the tenacity and a reduction in the elongation of the hammered bar. Their experiments were not, however, extended to annealed or even to normalised bars, and their results are not very consistent. Kalmus and Blake (4A) found in the case of the carbonless alloy Fe_2 Co that the alloy was brittle, although fairly strong. After forging, it was stronger than pure iron, but after annealing, showed approximately the same tensile strength as that metal. The medium alloy steels of high cobalt content which are on the market at the present time are extremely brittle in the annealed state, and considerable care is necessary in machining. A fine toothed saw, with light cut and light feed, is necessary to avoid breaking and chipping the edges. On the other hand, the metal is not unduly hard and the saws usually have a fairly long life. The air hardening high alloy steels on the other hand are tough and strong, and can be machined without any fear of mechanical breakage, but as the steels are relatively hard (Brinell number 300–350) a slow cutting speed, and a strong stiff cutter must be used, and the machine should be of robust construction. The feed employed may be the maximum which the machine and cutter will stand without breakage.

(3) *Cracking and Distortion in Hardening.*—Although the early attempts made in England to produce a cobalt-carbon steel gave much trouble through hardening cracks none of the steels in regular use at present give any trouble of this nature. The oil hardening steels are liable to give a certain amount of trouble if the temperature of the quenching oil is too low, or if the steel is heated too rapidly, but it is rarely that this trouble becomes serious, and it is probably much less a factor to be reckoned with than in the case of the ordinary tungsten steels. The air hardening steels are, of course, entirely free from any trouble due to cracking, and are remarkably free from distortion. This, together with their non-scaling properties, renders their handling a very simple proposition. They can in general be finished completely to size prior to hardening, even although quite narrow manufacturing limits are called for and the elaborate cooling jigs necessary with certain types of quenching steels are never required. They are somewhat prone to develop surface cracks if wet ground after hardening, although these cracks do not affect the magnetic properties in any way.

(4) *Mechanical Strength and Hardness in Finished State.*—Although there is little or no numerical data extant dealing with this, it may be stated that this is practically the same as that of a high grade alloy steel of similar carbon content, *i.e.*, a tensile strength of approximately 80 to 100 tons per square inch, no elongation or reduction in area, and a Brinell number of 600–700. It is generally just possible to touch the corners of a cobalt steel magnet with a hard file. The hardness of a steel is, therefore, not increased by the addition of cobalt in the same way that the coercive force is increased, so that the rough relation between hardness and coercive forces, which exists in the case of a plain carbon steel does not here apply. It is but rarely that a permanent magnet is called upon to take any considerable mechanical stress so that its mechanical strength, provided it is above a very modest limit, is not usually of importance. In one application, however, where cobalt steel magnets have been used in a rotor running at speeds up to 10,000 r.p.m., no mechanical trouble of any kind whatever has been experienced, even at speeds up to 50 per cent. in excess of the normal.

(To be continued.)

* For explanation of triple treatment see section following on heat-treatment.

INDIAN TRADE STATISTICS.—The trade returns of British India for the month of May, 1924, as issued by the Department of Overseas Trade, show small increases in the values of imports and re-exports, in conjunction with a decrease in exports as compared with the preceding month. The imports of private merchandise during May were valued at Rs. 20·60 lakhs, an increase of Rs. 0·33 lakhs, and the re-exports were increased by Rs. 0·6 lakhs to Rs. 1·32 lakhs. The value of the exports of Indian produce and manufactures declined from Rs. 29·43 lakhs in April to Rs. 27·73 lakhs in May, the reduction amounting to about 5·8 per cent. As compared with May, 1923, the imports of manufactured articles increased by Rs. 0·55 lakhs to Rs. 16·58 lakhs, while raw materials imports fell by Rs. 0·8 lakhs to Rs. 1·44 lakhs. Under the latter heading, coal and mineral oil imports were both lower, while raw cotton imports were higher, and, among manufactured articles, cotton-piece goods showed a considerable increase. There were, however, notable decreases in the imports of machinery, railway plant and rolling-stock, matches and electrical instruments. Metals, on the other hand, were imported in larger quantities. The British share in Indian trade has diminished during the year with respect to both imports and exports, the proportion of imports being 64·4 per cent. for May, 1923, and 60·1 per cent. for May of this year. The corresponding figures for the export trade were 20·5 per cent. and 19 per cent. for the two periods, respectively.

MELTING FOUNDRY IRON.—A series of tests in the making of synthetic cast iron in a commercial electric furnace has been completed by engineers of the United States Department of the Interior at the Seattle, Wash., Experiment Station of the Bureau of Mines. Both synthetic grey iron and mild steel were produced in alternating runs without trouble. Miscellaneous steel scrap of all kinds was charged into the furnace to produce various grades of iron. The results show that, under the conditions in this foundry, the synthetic product can compete with cupola iron, and is superior in quality and strength. These results will be applied in the melting of sponge iron, and in the melting of scrap at foundries. The experiments were made in a commercial direct-arc, acid-lined furnace of 3,000 lb. capacity. Soft machinable iron with a transverse strength of 5,600 lb. on a standard bar was repeatedly made. Without the opportunity for direct comparison, it seems apparent that carburization is more difficult in an acid-lined furnace than on a basic hearth. Retort carbon, clean crushed coke with about 14 per cent. ash, and coke breeze containing considerable ash and dirt were compared as carburizers, with the result that the retort carbon was found to be decidedly superior to the crushed coke, and the coke breeze just as definitely inferior to the other two. Except for its bulkiness, which makes charging more difficult, tin-plate scrap was melted as readily as other steel scrap. Under normal commercial conditions, excepting only those where some unusual trouble or delay was encountered, the average power consumption was 710 kw.h. per ton. That figure could be reduced by at least 100 kw.h. under more nearly ideal conditions. All these results corroborate exactly the results obtained in experimental work on synthetic gray iron previously made by the Bureau.